



KWAZULU-NATAL PROVINCE

EDUCATION
REPUBLIC OF SOUTH AFRICA

CURRICULUM GRADE 10 -12 DIRECTORATE

NCS (CAPS) SUPPORT

SOLUTIONS

LAST PUSH REVISION TEACHER DOCUMENT



PHYSICAL SCIENCES: PAPER 1 & 2

GRADE 12

2025

**VERTICAL PROJECTILE MOTION
SOLUTIONS
MULTIPLE CHOICE QUESTIONS**

- 1.1 B ✓✓ (2)
1.2 C ✓✓ (2)
1.3 D ✓✓ (2)
1.4 A ✓✓ (2)
1.5 C ✓✓ (2)

LONG QUESTIONS

QUESTION 1

- 1.1 $9,8 \text{ m} \cdot \text{s}^{-2}$ ✓ (1)

1.2.1 $\Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2$ ✓
 $2 = v_i(0,125) + \frac{1}{2}(9,8)(0,125)^2$ ✓
 $v_i = 15,39 \text{ m} \cdot \text{s}^{-1}$

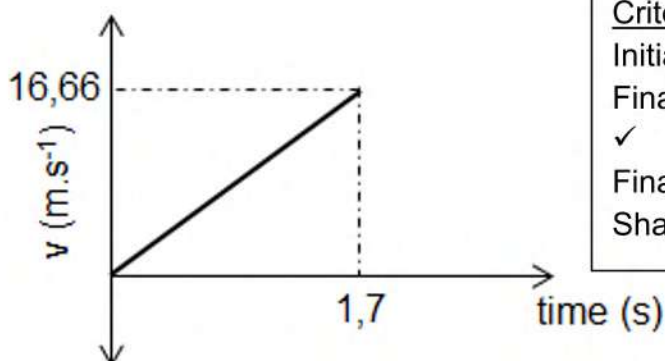
$v_f^2 = v_i^2 + 2a\Delta y$
 $(15,39)^2 = (0)^2 + 2(9,8)(\Delta y)$ ✓
 $\Delta y = 12,08 \text{ m}$
 $h = 12,08 + 2$ ✓
 $= 14,08 \text{ m}$ ✓



1.2.2 $\Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2$ ✓
 $14,08 \text{ ✓} = 0(\Delta t) + \frac{1}{2}(9,8)(\Delta t)^2$ ✓
 $\Delta t = 1,7 \text{ s}$ ✓

1.2.3 $v_f = v_i + a\Delta t$ ✓
 $= 0 + (9,8)(1,7)$ ✓
 $= 16,66 \text{ m} \cdot \text{s}^{-1} \text{ downwards}$ ✓

1.3



Criteria

- Initial velocity = $0 \text{ m} \cdot \text{s}^{-1}$ ✓
Final velocity = answer to 1.2.3 ✓
Final time = answer to 1.2.2 ✓
Shape: Straight line ✓

(4)
[17]

QUESTION 2

2.1 An object which has been given an initial velocity and then it moves under the influence of the gravitational force only. ✓✓ (2)

2.2 Distance = area under graph OR $\frac{1}{2}bh$ ✓
 $= \frac{1}{2} \times 0,8 \checkmark \times 7,84 \checkmark$
 $= 3,14 \text{ m } \checkmark$ (4)

2.3 0,2 seconds ✓ (1)

2.4 $F_{\text{net}} = \frac{\Delta p}{\Delta t}$
 $F_{\text{net}} = \frac{m\Delta v}{\Delta t} \checkmark$
 $F_{\text{net}} = \frac{0,175(1,53 - 7,84) \checkmark}{0,2 \checkmark}$
 $= -5,52 \text{ N}$
 $= 5,52 \text{ N upwards } \checkmark$ (4)

2.5 $v_f = v_i + a\Delta t \checkmark$
 $0 = 1,53 + (9,8)(0,7) \checkmark$
 $= 8,39 \text{ m}\cdot\text{s}^{-1} \checkmark$
 $a = \frac{y_2 - y_1}{x_2 - x_1} \checkmark$
 $9,8 = \frac{v_f - 1,53}{1,7 - 1} \checkmark$
 $V_f = 8,39 \text{ m}\cdot\text{s}^{-1} \checkmark$ (3)

2.6 Equal to ✓ (1)

[15]

QUESTION 3

3.1 BALL B

$$\Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2 \checkmark$$

$$12 = 18 \Delta t + \frac{1}{2} (-9,8) \Delta t^2 \checkmark$$

$$\Delta t = 0,88 \text{ s or } 2,8 \text{ s}$$

Select $\Delta t = 0,88 \text{ s}$ since Ball B is moving upwards when they meet at P

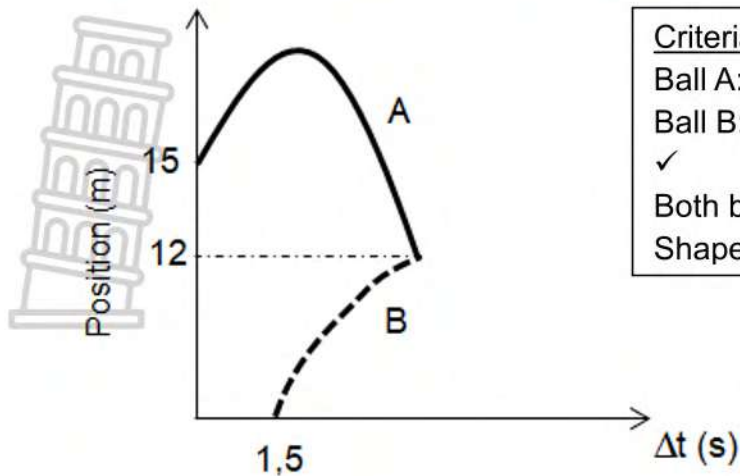
BALL A

$$\Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$-3 \checkmark = v_i(0,88 + 1,5 \checkmark) + \frac{1}{2} (-9,8)(0,88 + 1,5)^2 \checkmark$$

$$v_i = 10,4 \text{ m}\cdot\text{s}^{-1} \text{ upwards } \checkmark$$
 (6)

3.2



Criteria

Ball A: Start at 15 m ✓

Ball B: Start from x-axis at 1,5 s ✓

Both balls meet at 12 m ✓

Shape: Graph A ✓

(5)
[11]

QUESTION 4

4.1 Motion in which the only force acting is gravitational force. ✓✓

(2)

4.2 No ✓

(1)

4.3.1 $\Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2$ ✓

$15 = 3,4(\Delta t) + \frac{1}{2}(9,8)(\Delta t)^2$ ✓

$\Delta t = 1,44$ s ✓

(3)

4.3.2 $\Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2$ ✓

$= 3,4(1,44) + \frac{1}{2}(0)(1,44)^2$ ✓

$= 4,896$ m

Height = $15 - 4,896$ ✓

$= 10,1$ m ✓

(4)

4.4 $v_f = v_i + a \Delta t$ ✓

$0 = -7,2 + (9,8) \Delta t$ ✓

$\Delta t = 0,73$ s

$t_3 = 1,44 + 0,2 + 0,73$ ✓

$= 2,37$ s ✓

(4)

[14]

QUESTION 5

5.1.1 $v_f^2 = v_i^2 + 2a\Delta y$ ✓

$(0)^2 = v_i^2 + 2(-9,8)(\frac{1}{4}H)$ ✓

$v_i = \sqrt{4,9H}$ ✓

(4)

5.1.2 $v_f = v_i + a \Delta t$ ✓

$0 = v_i + (-9,8)(2,33 - T)$ ✓

(3)

$$v_i = 22,834 - 9,8T \checkmark$$

$$5.2 \quad \sqrt{4,9H} = 22,834 - 9,8T \checkmark$$

$$H = \frac{(22,834 - 9,8T)^2}{4,9}$$

$$5.3 \quad \Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2 \checkmark$$

$$-H \checkmark = 5(T) + \frac{1}{2}(-9,8)(T)^2 \checkmark$$

$$H = 4,9T^2 - 5T \checkmark$$

$$5.4 \quad 4,9T^2 - 5T \checkmark = \frac{(22,834 - 9,8T)^2}{4,9} \checkmark$$

$T = 1,76 \text{ s}$ or $T = 4,11 \text{ s}$ (Reject 4,11s since T is less than 2,33 seconds)

$$T = 1,76 \text{ s} \checkmark$$

Criteria

Graph A: $v = 19 \text{ m.s}^{-1}$ at $t = 0 \text{ s}$ and $v = 0 \text{ m.s}^{-1}$ at $t = 1,94 \text{ s}$ ✓

Graph B: Starts at $t = 3,30 \text{ s}$ and $v = 0 \text{ m.s}^{-1}$ ✓

(4)

(3)

[15]

QUESTION 6

6.1 Weight / Gravitational force ✓

(1)

$$6.2.1 \quad t = 0,67 - 0,64 \checkmark$$

$$= 0,03 \text{ s} \checkmark$$

(2)

6.2.2

$$t = \frac{1,9 - 0,67}{2} \checkmark$$

$$= 0,62 \text{ s} \checkmark$$

(2)

$$6.2.3 \quad v_f = v_i + a \Delta t \checkmark$$

$$0 = v_i + (-9,8)(0,62) \checkmark$$

$$v_i = 6,08 \text{ m.s}^{-1} \checkmark$$

(3)

$$6.2.4 \quad v_f^2 = v_i^2 + 2a \Delta y \checkmark$$

$$(0)^2 = v_i^2 + 2(-9,8)(1,2) \checkmark$$

$$v_i = 4,85 \text{ m.s}^{-1}$$

$$\Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2 \checkmark$$

$$1,2 = 4,85 \Delta t + \frac{1}{2}(-9,8) \Delta t^2 \checkmark$$

$$\Delta t = 0,49 \text{ s}$$

$$t = 1,97 + 2 \times 0,49 \checkmark$$

$$= 2,95 \text{ s} \checkmark$$

(6)

[14]

SOLUTIONS – WORK, ENERGY & POWER

QUESTION 1

- 1.1 B ✓✓ (2)
 1.2 C ✓✓ (2)
 1.3 A ✓✓ (2)
 1.4 B ✓✓ (2)

[8]

QUESTION 2

- 2.1 Backwards/behind him ✓ (1)

- 2.1.2 Newton's third Law of ✓ motion

When one body exerts a force on a second body, the second body exerts a force of equal magnitude ✓ in the opposite direction on the first body. ✓ (3)

- 2.3 $W_{\text{net}} = \Delta K$ ✓

$$W_g + W_f = \Delta K$$

$$F_g \Delta x \cos \theta + f \Delta x \cos \theta = \Delta K$$

$$(57)(9,8)(4) \cos 180^\circ \checkmark + 40 \Delta x \cos 180^\circ \checkmark = 0 - \frac{1}{2} (57)(6^2) \checkmark$$

$$\Delta x = -30,21 \text{ m}$$

$$\sin \theta = \frac{4}{30,21}$$

$$\theta = 7,61^\circ \checkmark$$

(5)

- 2.4 $W_{\text{net}} = \Delta K$ ✓

$$W_T + W_g + W_f = \Delta K$$

$$(80)(5)(4) \cos 0^\circ \checkmark + (15)(5) \cos 180^\circ \checkmark =$$

$$(4)(9,8) \sin 30^\circ (5) - (4)(9,8)(0) \checkmark + \frac{1}{2} (4)v_f^2 - \frac{1}{2} (4)(3)^2 \checkmark$$

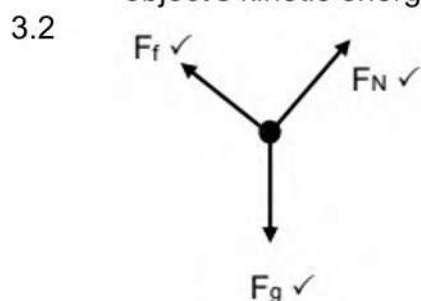
$$v_f = 11,07 \text{ m} \cdot \text{s}^{-1} \checkmark$$

(6)

[15]

QUESTION 3

- 3.1 The net work done on an object by a force is equal to the change in the object's kinetic energy. ✓✓ (2)



Accepted labels	
F_g ✓	W/F _w /weight/mg / gravitational force
F_f ✓	(Kinetic) friction / f/f _k
F_N ✓	F _{normal} /Normal/N

(3)

- 3.3 $W_{\text{net}} = (W_{F_{\text{normal}}}) + W_{\text{friction}} + W_{F_{\text{gravity}}}$ ✓

$$W_{\text{net}} = (0) + \mu_k N \cdot \Delta x \cdot \cos \theta + mg \cdot \Delta x \cdot \cos \theta$$

$$W_{\text{net}} = 0 + (0,42)(850)(9,8)(\cos 30^\circ) \checkmark + (200)(\cos 180^\circ) \checkmark + (850)(9,8)(200)(\cos 60^\circ) \checkmark$$

$$W_{\text{net}} = (-605\,975,2955) + 833\,000$$

$$W_{\text{net}} = 227\,024,7045 \text{ (or } 227\,024,7) \text{ J } \checkmark$$

(5)

$$3.4 \quad \Delta E_K \text{ from B to C} = E_{Kf} - E_{Ki} \quad (7)$$

$$- 108\,950 = E_{Kf} - 227\,024,7045 \quad \checkmark$$

$$E_{Kf} \text{ at C} = 118\,074,7045$$

$$W_{\text{net}} = \Delta E_K \quad \checkmark$$

$$W_{F_{\text{normal}}} + W_{F_{\text{gravity}}} + W_{F_{\text{friction}}} + W_{F_{\text{brakes}}} = \Delta E_K$$

$$0 + 0 + \mu_k N \cdot \Delta x \cdot \cos \theta + F_{\text{brakes}} \cdot \Delta x \cdot \cos \theta = E_{Kf} \text{ at D} - E_{Ki} \text{ at C}$$

$$0 + 0 + (0,42)(850)(9,8) \checkmark (50)(\cos 180^\circ) \checkmark + F_{\text{brakes}} \cdot (50)(\cos 180^\circ) \checkmark = 0 - 118\,074,7045 \quad \checkmark$$

$$F_{\text{brakes}} = -1137,106 \text{ N}$$

$$\text{magnitude of } F_{\text{brakes}} = 1137,106 \text{ N} \quad \checkmark$$

[21]

QUESTION 4

$$4.1 \quad \Delta U + \Delta K = 0 \quad \checkmark$$

$$(5)(9,8)(5) + 0 \checkmark + (0 + \frac{1}{2}(5v_f^2)) \checkmark \quad g = 0$$

$$v_f = 2\sqrt{\times 9,8 \times 5}$$

$$= 9,90 \text{ m} \cdot \text{s}^{-1} \checkmark (9,899 \text{ m} \cdot \text{s}^{-1}) \quad (4)$$

(4)

4.2

$$W_{nc} = \Delta U + \Delta K \quad \checkmark \quad F \Delta x \cos \theta = \Delta U + \Delta K$$

$$(18 \Delta x \cos 180^\circ) = (5)(9,8)(3-0) \checkmark + \frac{1}{2}(5)(0 - 9,90^2) \checkmark$$

$$\Delta x = 5,4458 \text{ m} \quad \checkmark$$

$$\theta = \sin^{-1} \checkmark \frac{3}{5,4458}$$

$$\theta = 33,43^\circ \quad \checkmark$$

(7)

QUESTION 5

$$5.1 \quad \text{A system on which the net external force is zero.} \quad \checkmark \checkmark \quad (2)$$

$$5.2 \quad (U + K)_A = (U + K)_B \quad \checkmark$$

$$mgh + \frac{1}{2}mv^2 = mgh + \frac{1}{2}mv^2$$

$$gh + \frac{1}{2}(v_i)^2 = gh + \frac{1}{2}vf^2$$

$$(9,8)(0,67) + \frac{1}{2}(0)^2 \checkmark = 0 + \frac{1}{2}vf^2 \quad \checkmark$$

$$v_f = 3,6238 \text{ m} \cdot \text{s}^{-1}$$

$$m_b v_{is} + m_c v_{ic} = m_b v_{fs} + m_c v_{fc} \quad \checkmark$$

$$5(3,6238) + 0 \checkmark = 5v_{fs} + 2(4,95) \quad \checkmark$$

$$v_{fs} = 1,6438 \text{ m} \cdot \text{s}^{-1} \quad \checkmark$$

(6)

$$5.3 \quad (U + K)_{\text{before}} = (U + K)_{\text{after}} \quad \checkmark$$

$$mgh + \frac{1}{2}mv^2 = mgh + \frac{1}{2}mv^2$$

$$0 \checkmark + \frac{1}{2}(5)(1,6438)^2 \checkmark = (5)(9,8)h + 0 \quad \checkmark$$

$$h = 0,138 \text{ m} \quad \checkmark$$

- 5.4 Some of the ball's mechanical energy is transferred to the block. ✓ ✓
- 5.5 The net/total work done on an object is equal to the change in the object's kinetic energy. ✓ ✓
- 5.6 $W_{nc} = \Delta E_K + \Delta U$ ✓
 $W_{nc} = \Delta E_K + \Delta E_P$
 $W_f = \frac{1}{2} (2)(2^2 - 4,95^2)$ ✓ + $(2)(9,8)(0,5 - 0)$ ✓
 $= -10,7 \text{ J}$ ✓

[22]

QUESTION 6

- 6.1 A force is non-conservative if the work it does/done on an object which is moving between two points depends on the path taken. ✓ ✓

(2)

- 6.2 $W_{net} = \Delta K$ ✓

$$mg \sin \theta \Delta x \cos \theta + W_f + W_F = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$$

$$(20)(9,8)(\sin 18^\circ)(15,6) \cos 180^\circ + (13,5)(15,6) \cos 180^\circ + (96,8)(15,6) \cos 0^\circ$$

$$= \frac{1}{2} (20)(v_f^2 - 0)^2$$
 ✓

$$v_f = 5,96 \text{ m} \cdot \text{s}^{-1}$$
 ✓

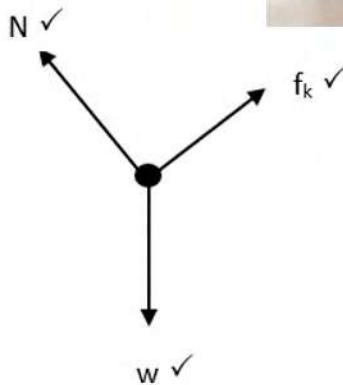
(5)

- 6.3 $P_{ave} = F v_{ave}$ ✓

$$= 96,8 \left(\frac{0 + 5,96}{2} \right)$$
 ✓

$$= 288,46 \text{ W}$$
 ✓

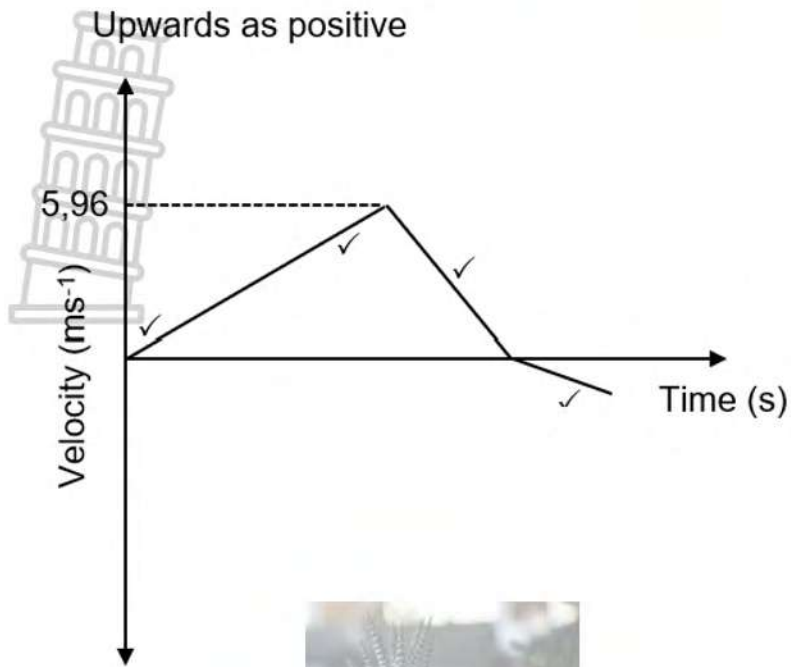
(3)



- 6.4

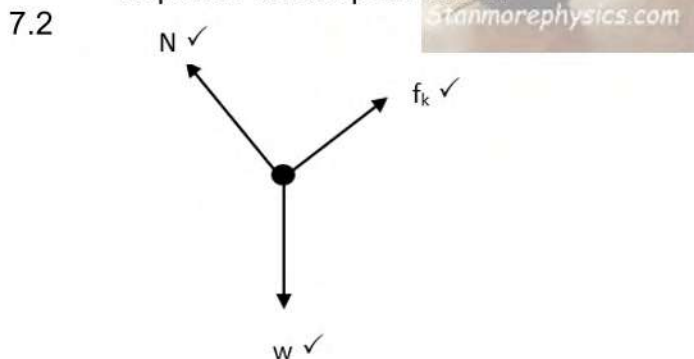
(3)

(4)



QUESTION 7

7.1 A force for which the work done in moving an object between two points depends on the path taken. ✓ ✓



7.3 The net workdone on an object is equal to the change in the object's kinetic energy. ✓ ✓

7.4.1 $W_{nc} = \Delta E_K + \Delta E_P$ ✓

$$W_f = \Delta E_K + \Delta E_P$$

$$W_f = \frac{1}{2} mv_f^2 - \frac{1}{2} mv_i^2 + mgh_2 - mgh_1$$

$$2,5 \times \frac{5}{\sin 10} \cos 180^\circ \checkmark = \frac{1}{2} \times 2 \times v_f^2 - 1,5^2 \checkmark + 2 \times 9,8 \times 0 - 2 \times 9,8 \times 5 \checkmark$$

$$v_f = 5,32 \text{ m.s}^{-1} \checkmark$$

7.4.2 $f_k = \mu_k N$

$$2,5 = \mu_k \times 2 \times 9,8 \cos 10^\circ$$

$$\mu_k = 0,13$$

$$W_f = \Delta E_k + \Delta E_p$$

$$W_f = \frac{1}{2} mv_f^2 - \frac{1}{2} mv_i^2 + mgh_2 - mgh_1$$

$$0,13 (2 \times 9,8) \times \cos 180^\circ \checkmark = \frac{1}{2} \times 2 \times 0^2 - \frac{1}{2} \times 2 \times 5,32^2 \checkmark + 0$$

$$\Delta x = 11,11 \text{ m} \checkmark$$

[17]

(2)

(3)

(2)

(5)

(5)

[14]

SOLUTIONS
CHEMICAL EQUILIBRIUM
QUESTION 1

- 1.1 B✓✓
1.2 C✓✓
1.3 C✓✓
1.4 D✓✓
1.5 B✓✓
1.6 A✓✓
1.7 A✓✓
1.8 A✓✓
1.9 B✓✓
1.10 C✓✓

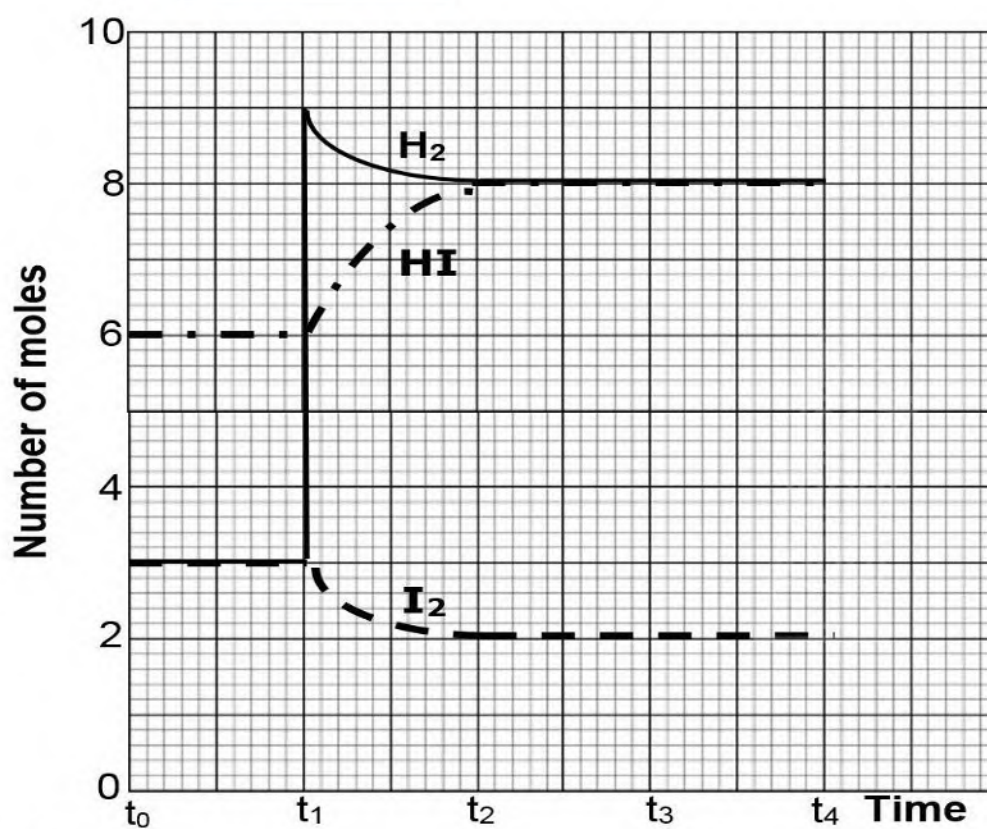


[20]

QUESTION 2

- 2.1 (6 moles of) H_2 was added. ✓✓
2.2

(2)



Criteria

- t_0 to t_1 all correct and constant ✓

- At t_1 , H_2 increases to 9✓
- Between t_1 and t_2 , H_2 gets to 8✓, HI gets to 8✓, I_2 gets to 2✓
- t_2 to t_3 all constant✓

Note: If the transitions from t_1 to t_2 are incorrectly shown, take off max 1 mark. (6)

2.3

- The reaction that removes H_2 or decreases $[H_2]$ is favoured✓
- i.e. the forward reaction is favoured✓
- The amounts of (H_2 and) I_2 decrease✓
- and the amount of HI increases✓

(4)

2.4

$$K_c = \frac{[HI]^2}{[H_2][I_2]} \quad \checkmark \quad \text{correct } K_c \text{ expression}$$

Divide all moles by 2 to get concentration✓

Before t_1

$$K_c = \frac{3^2}{(1,5)(1,5)} = 4$$

Before t_1

$$K_c = \frac{4^2}{(1)(4)} = 4$$

- Substitute (concentration values) $\times 2$ ✓
- Same correct answer (4) ✓
- K_c does not change $\therefore$ not a temperature change✓

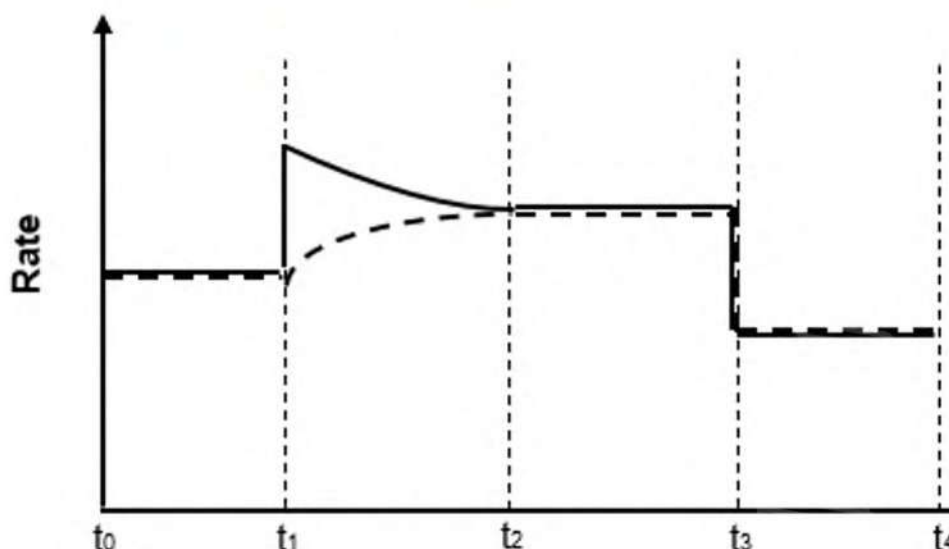
(5)

2.5

No change to number of moles at t_3 ✓✓

(2)

2.6



- $t_0 - t_1$ rates equal✓
- At t_1 , rate of forward increases✓
- $t_2 - t_3$ both rates equal and higher than between t_0 and t_1 ✓
- At t_3 both rates decrease by same amount✓
- Then continue equal and lower✓

(5)

[25]

QUESTION 3

3.1 False✓ (1)

3.2 The rate of the forward reaction✓✓ (2)

3.3 Constant✓ (1)

3.4 A temperature increase causes an endothermic reaction to be favoured because it will absorb heat and thereby reduce the temperature✓

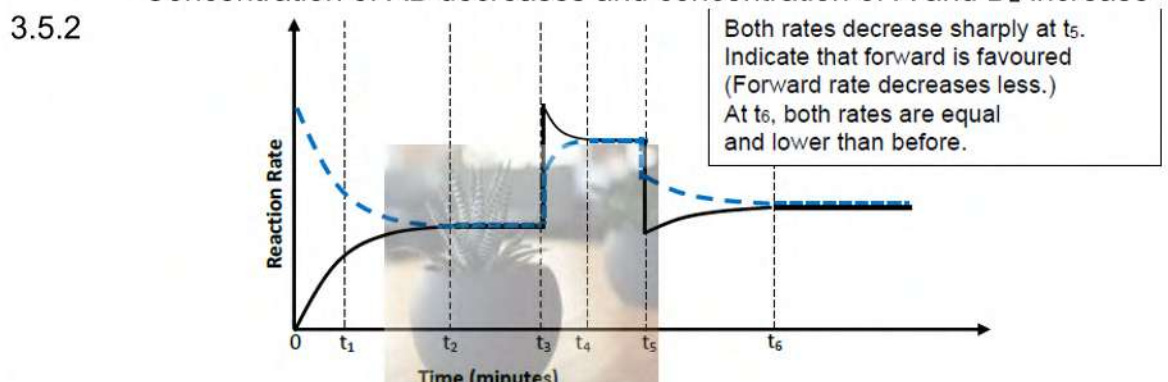
The graph shows that the reverse reaction is favoured✓ (3)

The forward reaction is exothermic✓

3.5.1 The system favours the reaction towards more gas moles.✓

The forward reaction is favoured✓

Concentration of AB decreases and concentration of A and B₂ increase✓ (3)



3.6.1 $K_c = \frac{[A]^2[B_2]}{[AB]^2}$ ✓✓ (2)

3.6.2 $1,56 \times 10^{-3} \checkmark = \frac{(0,05)^2(0,025)}{[AB]^2} \checkmark$
 $[AB] = 0,2 \text{ mol} \cdot \text{dm}^{-3}$ (2)

3.6.3

R(ratio)	2AB(g)	⇌	2A(g)	+	B ₂ (g)
I(initial)	X		0		0
C(change)	-0,05		+0,05		+0,025
E(equilibrium)	0,2		0,05		0,025

$$X - 0,05 = 0,2 \checkmark$$

$$X = [AB]_{\text{initial}} = 0,25 \text{ mol} \cdot \text{dm}^{-3} \checkmark \checkmark \quad (3)$$

[20]

QUESTION 4

4.1 That there is a much larger amount of reactants than products✓✓ (2)

- 4.2
- Internal combustion engines have extremely high temperatures✓
 - Le Châtelier's principle predicts the system will respond in order to decrease the temperature✓
 - Thus, the forward reaction is (initially) favoured as it is endothermic and thus consumes heat✓

- Increasing the amount of nitrogen monoxide✓ (4)
- 4.3 Remains the same✓✓ (2)
- 4.4 Increase✓✓ (2)
- 4.5.1 $K_c = \frac{[\text{NO}]^2}{[\text{O}_2][\text{N}_2]}$ ✓ (1)

4.5.2

R	N ₂	+	O ₂	⇌	2NO
I	$4,5 \times 10^{-3}$		$4,5 \times 10^{-3}$		0
C	$(-x)$		$(-x)$		$+2x$
E	$4,5 \times 10^{-3} - x$		$4,5 \times 10^{-3} - x$		$2x$
[]	$\frac{4,5 \times 10^{-3} - x}{0,2}$		$\frac{4,5 \times 10^{-3} - x}{0,2}$		$\frac{2x}{0,2}$

$$K_c = \frac{[\text{NO}]^2}{[\text{O}_2][\text{N}_2]}$$

$$1,11 \times 10^{-5} = \frac{\left(\frac{2x}{0,2}\right)^2}{\left(\frac{4,5 \times 10^{-3} - x}{0,2}\right)\left(\frac{4,5 \times 10^{-3} - x}{0,2}\right)}$$

$$X = 7,45 \times 10^{-6} \text{ mol} \cdot \text{dm}^{-3} \checkmark \quad (6)$$



- 4.7
- Le Châtelier's principle predicts the system will respond in order to increase the pressure
 - The reverse reaction is (initially) favoured as it produces more gas particles
 - Decreasing the amount of NO₂
 - Causing the brown colour to fade
- (4)
- [24]

QUESTION 5

- 5.1 When the equilibrium in a closed system is disturbed, the system will reinstate a new equilibrium by favouring the reaction that will oppose the disturbance. ✓✓ (2)
- 5.2.1 Adding more CH₄ will increase the concentration of CH₄✓
The forward reaction is favoured✓
The yield of H₂ will increase✓ (3)
- 5.2.2 An increase in pressure favours the reaction that produces the lower number of moles/number of molecules✓
The reverse reaction is favoured✓ (3)
The yield of H₂ decreases✓
- 5.3.1 The reaction is in (dynamic/chemical) equilibrium✓/ the rates of the forward and reverse reactions are equal✓ (2)

5.3.2 MARKING CRITERIA:

- Mole at equilibrium 0,6✓
- Use mole ratio 1 : 1 : 1 : 3✓
- Subtract CH₄ , H₂O and add H₂✓
- Divide by 2 dm³✓
- Correct K_c expression (formulae in square brackets) ✓
- Substitution of concentrations into correct K_c expression✓
- Final answer (range 1,82 – 1,83) ✓
Option with concentration can also be used.

	CH ₄	+	H ₂ O	CO	H ₂
Initial amount (moles)	1,4		1,2	0	0
Change in amount (moles)	0,6		0,6	0,6	1,8✓ratio
Equilibrium amount (moles)	0,8		0,6✓	0,6	1,8✓
Concentration at equilibrium	0,4		0,3	0,3	0,9✓

$$K_c = \frac{[\text{CO}] [\text{H}_2]^3}{[\text{CH}_4] [\text{H}_2\text{O}]}$$

$$= \frac{(0,3)(0,9)^3}{(0,4)(0,3)}$$

$$= 1,82✓$$

No K_c expression, correct substitution: Max. ⁶/7

No square brackets: Max. ⁶/7

Wrong K_c expression: Max ⁴/7

(7)

[17]

QUESTION 6

- 6.1 A system that is isolated from its surroundings. A system where substances cannot leave/escape the container.✓✓

(2)

6.2 CALCULATIONS USING NUMBER OF MOLES

Marking criteria

- Change n(H₂) = equilibrium n(H₂) = 0,02
- USING** ratio HI:H₂:I₂ = 2:1:1
- Equilibrium mole of I₂ = Change mole I₂ ✓
- Divide 0,02 by 5 AND multiplying 0,0316 by 5 ✓
- Correct K_c expression (formulae in square brackets) ✓
- Substitution of K_c 0,016
- Substitution of concentrations into K_c expression ✓
- Initial mole of HI = Equilibrium + Change = 0,198 mol ✓

	HI	H ₂	I ₂
Initial amount (moles)	0,198✓		0
Change in amount (moles)	0,04	0,02	0,02✓
Equilibrium amount (moles)	0,158	0,02✓	0,02
Concentration at equilibrium	0,0316	0,004	0,004

$$K_c = \frac{[I_2][H_2]}{[HI]^2}$$

$$0,016✓ = \frac{(0,004)^2}{[HI]^2}$$

$$[HI] = 0,0396 \text{ mol.dm}^{-3}$$

$$n(HI) = 5 \times 0,0316✓$$

$$= 0,158 \text{ mol}✓$$

6.3.1 Decreases✓

6.3.1 Remains the same✓

6.4 Endothermic✓

- K_c decreases with a decrease in temperature ✓
- Reverse reaction is favoured/concentration of reactants increases/ concentration of products decreases/yield decreases ✓

Decrease in temperature favours an exothermic reaction ✓

(8)

(1)

(1)

(4)

[16]

QUESTION 7

7.1.1 Increases ✓

7.1.2 Forward ✓

7.1.3 Reactants and products are all in the (same) gaseous phase ✓✓

7.1.4 Increase in temperature increases K_c. ✓

Increase in K_c indicates that the forward reaction has been favoured. ✓

Increase in temperature favours the endothermic reaction. ✓

Therefore, the forward reaction is endothermic. ✓

7.1.5 Add a catalyst. ✓ Decrease pressure OR Increases the volume of the container. ✓

(1)

(1)

(2)

(4)

(2)

7.2



	2SO ₂	O ₂	2SO ₃
Initial mol	8	y	0
Mol reacted	-2x	-x	+2x ✓
Mol at equil.	2	y-3 ✓	6
[] at equil.	1	$\frac{y-3}{2}$	3 ✓ (+2)

$$K_c = \frac{[SO_3]^2}{[SO_2]^2 [O_2]} \quad \text{correct } K_c \text{ expression}$$

$$9 = \frac{(3)^2}{(1)^2 (y-3)} \quad \text{correct substitution}$$

$$y = 5 \text{ mol } \checkmark$$

(6)

[16]

QUESTION 8



8.1.1 The reaction is in a state of dynamic equilibrium/ Rate of the forward reaction equals the rate of the reverse reaction. ✓✓ (2)

8.1.2 Less than ✓ (1)

8.1.3 t_1 ✓
the concentration of N₂ (g) was increased ✓ (2)

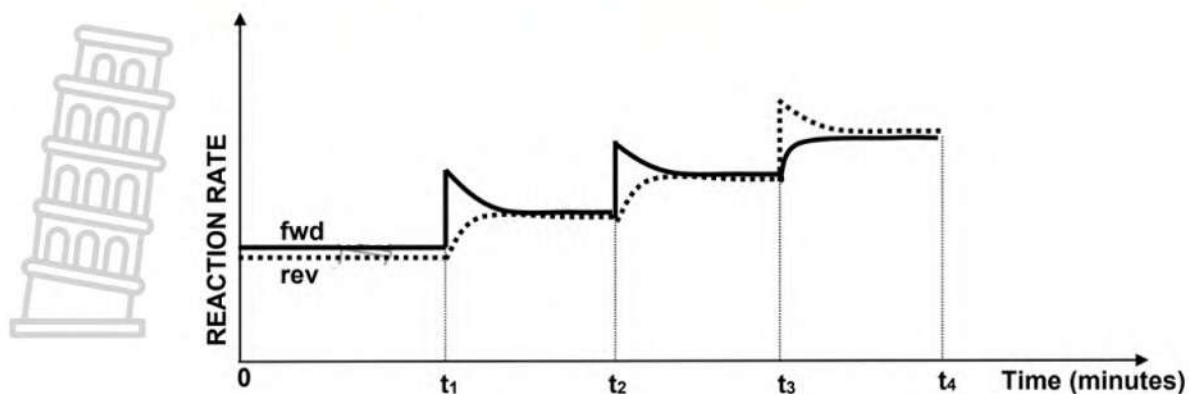
8.1.4 When an equilibrium in a closed system is disturbed, the system will re-instate a new equilibrium by favouring the reaction that will oppose the disturbance ✓✓ (2)

8.1.5 Temperature ✓ (1)

8.1.6 INCREASED ✓
According to the graph the concentration of the reactants increases OR the concentration of the products decrease. ✓
Therefore the reverse reaction / endothermic reaction is favoured. ✓ (According to Le Chatelier's Principle) an increase in temperature favours the endothermic reaction ✓ (4)

8.1.7 Marking criteria

- At t_1 , forward reaction is favoured (vertical upward climb of solid line) ✓
- At t_2 , forward reaction is favoured (vertical upward climb of solid line) ✓
- At t_3 , reverse reaction is favoured (vertical upward climb of broken line) Vertical upward increase in rates at t_2 , t_3 and t_4 . ✓
- Equilibrium rate at t_4 .> equilibrium rate at t_3 > equilibrium rate at t_2 ✓✓ (5)



8.2

	AO ₂	A ₂ O ₃	O ₂
Initial concentration	2	0	0
Change concentration	-4x = -0.2✓	+2x = +0.1✓	+x = +0.05✓
Equilibrium concentration (mol.dm ⁻³)	1.8✓	0.1✓	0.05✓

At equilibrium, AO₂ is 10% decomposed.

10% of 2 = 0.2

(6)

[23]

QUESTION 9

9.1 The stage in a chemical reaction when the rate of the forward equals the rate of the reverse reaction. ✓✓ (2)

9.2.1 2✓ (1)

9.2.2 1✓ (1)

9.2.3 3✓ (1)

9.3

OPTION 1

$$\left. \begin{aligned} [A] &= \frac{8}{3} = 2,67 \text{ mol} \cdot \text{dm}^{-3} \\ [B] &= \frac{4}{3} = 1,33 \text{ mol} \cdot \text{dm}^{-3} \\ [C] &= \frac{12}{3} = 4 \text{ mol} \cdot \text{dm}^{-3} \end{aligned} \right\} \text{Divide by } 3 \text{ dm}^3 \checkmark$$

$$K_c = \frac{[C]^3}{[A]^2[B]} \checkmark = \frac{(4)^3}{(2,67)^2(1,33)} \checkmark = 6,75 \checkmark$$

OPTION 2

	A	B	C
Initial quantity (mol)	16	8	0
Change (mol)	8	4	12
Quantity at equilibrium (mol)	8 ✓	4 ✓	12 ✓
Equilibrium concentration (mol·dm ⁻³)	$\frac{8}{3}$	$\frac{4}{3}$	$\frac{12}{3}$

Divide by
3 dm³ ✓

$$K_c = \frac{[C]^3}{[A]^2[B]} \checkmark = \frac{(4)^3}{(2,67)^2(1,33)} \checkmark = 6,75 \checkmark$$

(7)

9.4 Endothermic ✓

- (an increase in temperature) favours the reverse reaction. ✓
- An increase in the temperature favours an endothermic reaction. ✓

(3)

[15]

QUESTION 10

10.1

10.1.1 Remains the same ✓

(1)

10.1.2 Decreases ✓

(1)

10.1.3 Remains the same ✓

(1)



10.2

- When the volume is increased, the pressure decreases.
- According to Le Chatelier's principle, the system will favour the reaction that produces more moles of gas. ✓
- The forward reaction produces more moles of gas
- The forward reaction is favoured. ✓

(2)

10.3

- Mass of CO₂ reacted:
 - $\Delta m(C) = \text{Initial mass} - \text{Equilibrium mass}$
 - $\Delta m(\text{CO}_2) = 14.0 \text{ g} - 4.44 \text{ g} \checkmark = 9.56 \text{ g}$
- Moles of C reacted:
 - $n = m / M$
 - $n(C) = 9.56 \text{ g} / 12 \text{ g} \cdot \text{mol}^{-1} \checkmark = 0.797 \text{ mol}$
- Moles of C reacted (from mole ratio C:CO₂ is 1:1):
 - $n(\text{CO}_2) \text{ reacted} = 0.797 \text{ mol} \checkmark$
- Mass of C reacted:
 - $m = n \times M$
 - $m(C) = 0.797 \text{ mol} \times 44 \text{ g} \cdot \text{mol}^{-1} \checkmark = 35.07 \text{ g}$
- Initial mass of C (X):
 - $X = \text{Initial mass} - \text{Mass reacted}$
 - $X = 41.2 - 35.07 \checkmark = 6.13 \text{ g} \checkmark$

(6)

10.4



- Equilibrium moles:
 - $n(\text{CO}_2) = 6.13\text{g} / 44\text{ g}\cdot\text{mol}^{-1} = 0.139\text{ mol}$
 - $n(\text{CO}) \text{ formed} = 2 \times n(\text{CO}_2) \text{ reacted} \checkmark = 2 \times 0.797\text{ mol} = 1.594\text{ mol}$
- Equilibrium concentrations ($V = 3\text{ dm}^3$):
 - $[\text{CO}_2] = n / V = 0.139\text{mol} / 3\text{ dm}^3 = 0.046\text{ mol}\cdot\text{dm}^{-3}$
 - $[\text{CO}] = n / V = 1.594\text{ mol} / 3\text{ dm}^3 = 0.53\text{ mol}\cdot\text{dm}^{-3} \checkmark$

OR

	CO_2	2CO
Initial amount (moles)	0.936	0
Change in amount (moles)	0.797	1.594
Equilibrium amount (moles)	0.139	1.594
Concentration at equilibrium	0.046	0.53

- K_c calculation:
 - $K_c = [\text{CO}]^2 / [\text{CO}_2] \checkmark$
 - $K_c = (0.53^2) / (0.046) \checkmark$
 - $K_c = 6.10 \checkmark$

(5)

10.5 Y✓✓

(2)

10.6 Remains the same✓

(1)

[19]

QUESTION 11

11.1

Marking criteria:

If any one of the underlined key phrases in the **correct context** is omitted, deduct 1 mark.

The underlined phrases must be in the correct context.

(2)

When the equilibrium in a closed system is disturbed, the system will re-instate a new equilibrium by favouring the reaction that will cancel/oppose the disturbance.✓✓

11.2 (Chemical) equilibrium/Concentrations of reactants and products remain constant./Rate of the forward and reverse reactions are equal. ✓

(1)

11.3 Exothermic✓

(1)

- With an increase in temperature the endothermic reaction is favoured.✓
- The reverse reaction is favoured./ Equilibrium shifts to the left. / Reactants / $[\text{P}_2\text{Q}]$ increases OR Products / $[\text{PQ}_2]$ decreases.✓

(2)

11.5 Less than✓

(1)

11.6 **Marking criteria**



- Correct K_c expression
- Substitute 0.49 into the K_c expression
- Substitute equilibrium concentration (0.35) into the correct K_c expression
- Change in concentration/mole
- **USE** ratio $P_2Q : 2PQ_2 = 1 : 2$
- Substitute 2 dm³ in $n = cV$
- Final answer = 0.85 mol

	P_2Q	$2PQ_2$
Initial concentration (mol.dm ³)	X	0
Change in concentration (mol.dm ³)	0.175✓	0.35
Equilibrium concentration (mol.dm ³)	X- 0.175✓	0.35

$$K_c = \frac{[PQ_2]^2}{[P_2Q]} \checkmark \checkmark$$

$$\checkmark 0.49 = (0.35)^2 / (x - 0.175) \checkmark$$

$$X = 0.425 \text{ mol.dm}^{-3}$$

$$n(P_2Q) = cV$$

$$= 0.425 \times 2 \checkmark$$

$$= 0.85 \text{ mol} \checkmark$$

(8)

11.7 Pressure was decreased/ volume of the container was increased✓

(1)

11.8 Favours the reaction that produces more number of gas moles✓

(2)

$[P_2Q]$ increased✓

[18]

QUESTION 12

12.1

12.1.1 (The dynamic equilibrium when) the rate of the forward reaction equals the rate of the reverse reaction. ✓✓ (2 or 0) (2)

12.1.2 x✓ (1)

12.1.3 Decreased✓ (1)

12.1.4 The concentrations of (all) the gases decreased./The reverse reaction was favoured.✓ (1)

12.1.5 CO(g)/carbon monoxide (1)

12.1.6 The concentration of Z (CO) decreased with a decrease in the concentration of X (O₂). ✓

OR

(1)

The concentration of Z (CO) increased with an increase in the concentration of X (O₂)

12.1.7 Decreased ✓

(1)

12.1.8 • Concentration of products/Y/CO₂ increases. ✓

OR

Concentration of reactant/Z/X/CO/O₂ decreases. OR

The forward reaction is favoured.

(3)

- The forward reaction is exothermic. ✓
- A decrease in temperature favours the exothermic reaction. ✓

12.2 Marking criteria

(a) USING ratio: $n(\text{H}_2\text{O}) : n(\text{CO}) : n(\text{H}_2) : n(\text{CO}_2) = 1 : 1 : 1 : 1$ ✓

(b) $n(\text{CO})_{\text{eq}} = n(\text{CO})_{\text{initial}} - \Delta n(\text{CO})$, $n(\text{H}_2\text{O})_{\text{eq}} = n(\text{H}_2\text{O})_{\text{initial}} - \Delta n(\text{H}_2\text{O})$,
 $n(\text{CO}_2)_{\text{eq}} = n(\text{CO}_2)_{\text{initial}} + \Delta n(\text{CO}_2)$ AND $n(\text{H}_2)_{\text{eq}} = n(\text{H}_2)_{\text{initial}} + \Delta n(\text{H}_2)$ ✓

(c) Divide n_{eq} by the volume 2 dm³ ✓

(d) Correct K_c expression. ✓

(e) Substitute K_c value 4. ✓

(f) Substitute concentrations in K_c expression. ✓

(g) Substitute numerical values of x in $n(\text{CO})_{\text{initial}} - \Delta n(\text{CO})$ change ✓

(h) Substitute of 28 in $n = m/M$ ✓

(i) Final answer: 6,44 g ✓

Range: 6,44 – 6,72 g

(9)

	CO	H ₂ O	H ₂	CO ₂
Initial concentration (mol·dm⁻³)	0,3	0,3	0,05	0,05 ✓
Change (mol·dm⁻³)	x	X	x	x ✓
Equilibrium concentration (mol·dm⁻³)	0,3 + x	0,3 + x	0,05 - x	0,05 - x ✓

$$K_c = \frac{[\text{CO}_2][\text{H}_2]}{[\text{CO}][\text{H}_2\text{O}]}$$

$$4 = \frac{(0,05-x)(0,05-x)}{(0,3+x)(0,3+x)}$$

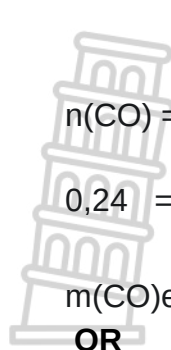
$$\sqrt{4} = \frac{(0,05-x)(0,05-x)}{(0,3+x)(0,3+x)}$$

$$x = -0,18 \text{ (0,183)}$$

$$x = -0,18 \text{ (0,183)}$$

$$[\text{CO}] = 0,3 + (-0,18) = 0,12 \text{ mol·dm}^{-3}$$

$$n(\text{CO})_{\text{eq}} = cV$$



$$= (0,12)(2) \checkmark$$

$$= 0,24 \text{ mol}$$

$$n(\text{CO}) = \frac{m}{M}$$

$$0,24 = \frac{m}{28} \checkmark$$

$$m(\text{CO})_{\text{eq}} = 6,72 \text{ g} \checkmark$$

OR

	CO	H ₂ O	CO ₂	H ₂
Initial amount (moles)	0,6	0,6	0,1	0,1
Change in amount (moles)	x	X	x	x
Equilibrium amount (moles)	0,6 + x	0,6 + x	0,1 - x	0,1 - x✓
Equilibrium concentration (mol·dm⁻³)	(0,6 + x)/2	(0,6 + x)/2	(0,1 - x)/2	(0,1 - x)/2 ✓

$$K_c = \frac{[\text{CO}_2][\text{H}_2]}{[\text{CO}][\text{H}_2\text{O}]} \checkmark$$

$$4 \checkmark = \frac{\{(0,1 - x)/2\} \cdot \{(0,1 - x)/2\}}{\{(0,6 + x)/2\} \cdot \{(0,6 + x)/2\}} \checkmark$$

$$x = -0,37$$

$$n(\text{CO})_{\text{eq}} = 0,6 + (-0,37) \checkmark$$

$$= 0,23 \text{ mol}$$

$$n(\text{CO})_{\text{eq}} = \frac{m}{M}$$

$$0,23 = \frac{m}{28} \checkmark$$

$$m(\text{CO})_{\text{eq}} = 6,44 \text{ g} \checkmark$$



[20]

GALVANIC CELLS: SOLUTIONS

QUESTION 1

1.1. D ✓✓

1.2. B ✓✓

1.3. C ✓✓

1.4. A ✓✓

1.5. D ✓✓

[10]

QUESTION 2

2.1 Chemical to Electrical ✓ (1)

2.2 $\text{Zn(g)} \mid \text{Zn}^{2+}(\text{aq}) \parallel \text{Ag}^+(\text{aq}) \mid \text{Ag(s)}$ ✓✓✓ (3)

2.3 The electrode where oxidation takes place. ✓✓ (2)

2.4 Silver ions. ✓ (1)

2.5 $\text{Zn(s)} + 2\text{Ag}^+(\text{aq}) \rightarrow \text{Zn}^{2+}(\text{aq}) + 2\text{Ag(s)}$ ✓✓✓ (3)

2.6 Concentration of the electrolyte 1mol.dm^{-3} ✓ (2)

Temperature $25^{\circ}\text{C} / 273\text{K}$ ✓ (2)

2.7 $E_{\text{cell}}^{\theta} = E_{\text{cathode}}^{\theta} - E_{\text{anode}}^{\theta}$ ✓
 $= (0,80) - (-0,76)$ ✓✓

$E_{\text{cell}}^{\theta} = 1,56\text{ V}$ ✓ (4)

[16]

QUESTION 3

3.1.1 Gold (III) ions ✓ or Au^{3+} (1)

3.1.2 $2\text{Cl}^- \rightarrow \text{Cl}_2(\text{g}) + 2\text{e}^-$ ✓✓ (2)

3.1.3 $\text{Pt(s)} \mid \text{Cl}^-(\text{aq}) \mid \text{Cl}_2(\text{g}) \parallel \text{Au}^{3+}(\text{aq}) \mid \text{Au(s)}$ ✓✓✓ (3)

3.2 $E_{\text{cell}}^{\theta} = E_{\text{cathode}}^{\theta} - E_{\text{anode}}^{\theta}$ ✓
 $0,14 = E_{\text{cathode}}^{\theta} - (1,36)$ ✓✓
 $= 1,50\text{ V}$ ✓ (4)

3.5.1 Smaller than. ✓

Decreases in potential difference due to internal resistance ✓ (2)

[12]

QUESTION 4

4.1 Temperature: 25 °C / 298 K ✓

Pressure: 101,3 kPa / $1,013 \times 10^5$ Pa / 1 atm / 100 kPa ✓

Concentration: 1 mol·dm⁻³ ✓

(3)

4.2.1 Cd(s) ✓ or Cadmium

(1)

4.2.2 $E_{\text{cell}}^{\theta} = E_{\text{cathode}}^{\theta} - E_{\text{anode}}^{\theta}$ ✓

0,13 ✓ = $E_{\text{cathode}}^{\theta} - (-0,4)$ ✓

= -0,27 V ✓

Q is Nickel ✓

(5)

4.3.1 $\text{Cd(s)} \rightarrow \text{Cd}^{2+}(\text{aq}) + 2\text{e}^{-}$ ✓✓

(2)

4.3.2 Pt ✓ or Platinum

(1)

4.4 Cd^{2+} ; Q^{2+} ; R_2 ✓

Compare Q^{2+} & Cd^{2+}	Q^{2+} is reduced / Cd is oxidised, therefore Q^{2+} is a stronger oxidising agent than Cd^{2+} ✓
Compare R_2 & Cd^{2+}	R_2 is reduced / Cd is oxidised, therefore R_2 is a stronger oxidising agent than Cd^{2+} ✓
Compare R_2 & Q^{2+}	The cell potential of combination II is higher than that of combination I; therefore, R_2 is a stronger oxidising agent than Q^{2+} . ✓

(4)

[16]

QUESTION 5

5.1 Chemical energy to electrical energy. ✓

(1)

5.2 Concentration of the electrolyte 1mol·dm⁻³ ✓

Temperature 25°C / 273K ✓

(2)

5.3 Mg ✓ or Magnesium

(1)

5.4 $\text{Mg(s)} \rightarrow \text{Mg}^{2+} + 2\text{e}^{-}$ ✓✓

(2)

5.5 $n_{\text{Mg}} = \frac{m}{M} = \frac{0,96}{24} \checkmark = 0,04 \text{ mol}$

$n_{\text{Fe}} = n_{\text{Mg}} \times \frac{2}{3} \checkmark$

$= 0,027 \text{ mol} \checkmark$

$m_{\text{Fe}} = n \times M$

$= 0,027 \times 56 \checkmark$

$= 1,51\text{g} \checkmark$

(5)

5.6 $E_{\text{cell}}^{\theta} = E_{\text{cathode}}^{\theta} - E_{\text{anode}}^{\theta} \checkmark$

$= (-0,04) - (-2,37) \checkmark \checkmark$

$= 2,33\text{V} \checkmark$

Yes✓, Bulb will light up.

(5)

5.7 Increase. ✓

(1)

5.8 Decrease✓

An increase in the concentration of Magnesium ions (Mg^{2+}) will favour the reverse reaction (the reaction that decreases the Mg^{2+} concentration). ✓

(2)

[19]

QUESTION 6

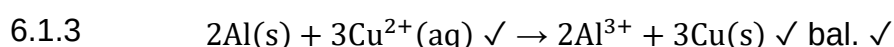
6.1.1 Increases ✓

The reaction is exothermic. /Energy (or heat) is released / $\Delta H < 0$. ✓

(2)

6.1.2 Aluminium is a strong reducing agent/stronger reducing agent ✓ than copper and will reduce the copper (II) ions to copper. ✓

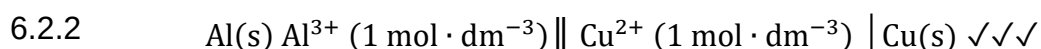
(2)



(3)

6.2.1 Aluminium ✓

(1)



(3)

6.2.3 $E_{\text{cell}}^{\theta} = E_{\text{cathode}}^{\theta} - E_{\text{anode}}^{\theta} \checkmark$

$= 0,34 - (-1,66) \checkmark \checkmark = 2,00\text{V} \checkmark$

(4)

6.2.4 zero V / 0V ✓ The circuit is open ✓

(2)

[17]

ELECTROLYTIC CELLS: SOLUTIONS

QUESTION 1

- 1.1. A ✓✓
- 1.2. C ✓✓
- 1.3. C ✓✓
- 1.4. D ✓✓
- 1.5. C ✓✓
- 1.6. C ✓✓

[12]

QUESTION 2

- 2.1 Oxidation is a loss of electrons ✓✓ (2)
- 2.2 A ✓ Cr^{3+} ions moves Towards A ✓
Or Reduction is taking place
Or Oxidation is taking place at B, B is positive, so A must be negative. (2)
- 2.3 $\text{Cr}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Cr}(\text{s})$ ✓✓ (2)
- 2.4 Cr is a stronger reducing agent than Ag (Silver) ✓✓
Or Ag⁺ is a stronger oxidizing agent. (2)

[8]

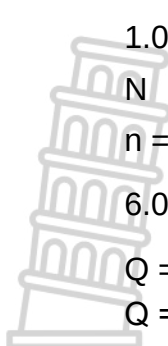
QUESTION 3

- 3.1.1 Battery ✓ or Power source (1)
- 3.1.2 Chlorine ✓ (1)
- 3.1.3 $2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$ ✓✓ (2)
- 3.1.4 Cl^- ✓ (or NaCl) (1)
- 3.2 $[\text{H}_3\text{O}^+] > 1 \times 10^{-7}$ ✓
Solution is alkaline ✓ (2)
- 3.3 Cu^{2+} is a stronger oxidizing agent ✓ than Na^+ and will be reduced ✓ to Cu ✓ (3)

[10]

QUESTION 4

- 4.1 A cell in which electrical energy is converted into chemical energy ✓✓ (2)
- 4.2 B ✓ (1)
- 4.3.1 $n(\text{Cu}) = \frac{m}{M}$
 $= \frac{32}{63.5}$ ✓
 $= 0.504 \text{ mol of Cu}$ ✓ (2)
- 4.3.2 $n(\text{Cu}) : n(\text{e}^-) = 1 : 2$ Therefore; $n(\text{e}^-) = 0.504 \times 2 = 1.008 \text{ mol}$ ✓
 $n(\text{Cu}) = \frac{N}{N_A}$



$$1.008 = \frac{N}{6.02 \times 10^{23}} \checkmark$$

$$N = 6.068 \times 10^{23} \text{ electrons}$$

$$n = \frac{Q}{qe}$$

$$6.068 \times 10^{23} = \frac{Q}{1.6 \times 10^{-19}} \checkmark$$

$$Q = 97090,56 \text{ C } \checkmark$$

$$Q = I \times \Delta t$$

$$97090,56 = I (3600) \checkmark$$

$$I = 26,97 \text{ A } \checkmark$$

- 4.4 Cu^{2+} is a stronger oxidizing agent $\checkmark$ than Zn^{2+} .
 Cu^{2+} is reduced $\checkmark$ to Cu. $\checkmark$ (3)
[14]

QUESTION 5

- 5.1 DC $\checkmark$ (1)
 5.2 Cathode $\checkmark$
 $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu} \checkmark\checkmark$ (3)
 5.3 Cu^{2+} is a stronger oxidising agent $\checkmark$ than Zn^{2+} ions $\checkmark$; therefore Zn^{2+} ions will not be reduced (to Zn). $\checkmark$ (3)
 5.4.1 (Chlorine) gas/ bubbles is/ are formed. $\checkmark\checkmark$ (2)
 5.4.2 Decreases $\checkmark\checkmark$ (2)
[11]

ELECTRODYNAMICS: SOLUTIONS

MULTIPLE CHOICE SOLUTIONS

- 1.1 C $\checkmark\checkmark$ (2)
 1.2 D $\checkmark\checkmark$ (2)
 1.3 A $\checkmark\checkmark$ (2)

QUESTION 1

- 1.1 Generator $\checkmark$
 No external power source $\checkmark$ (2)
 1.2 Coil $\checkmark$ (1)
 1.3 Good conductor of electricity $\checkmark$ (1)
 1.4 A to B $\checkmark\checkmark$ (2)



$$1.5.1 \quad f = \frac{1}{T} \checkmark \quad (3)$$

$$f = \frac{1}{0.02} \checkmark$$

$$= 50\text{Hz} \checkmark \text{ Type equation here.}$$

$$1.5.2 \quad V_{rms} = \frac{V_{max}}{\sqrt{2}} \checkmark$$

$$V_{rms} = \frac{250}{\sqrt{2}}$$

$$= 176.78\text{V}$$

$$I_{rms} = \frac{I_{max}}{\sqrt{2}}$$

$$= \frac{2}{\sqrt{2}}$$

$$= 1.41\text{A} \checkmark$$

$$P_{av} = V_{rms}I_{rms} \checkmark$$

$$= (176.78)(1.41) \checkmark$$

$$= 249.26\text{W} \checkmark$$



(5)

QUESTION 2

2.1 AC (generator) ✓ the ends of the coil are attached to slip rings ✓ (2)

2.2 From mechanical energy to electrical energy ✓ (1)

2.3.1 Brushes ✓ (1)

2.3.2 They conduct current from the slip rings to the external circuit. ✓ (1)

2.4 From X to Y ✓ (1)

2.5.1 0 V ✓ (1)

2.5.2 The rms current is the alternating current ✓ which dissipates/produces the same amount of energy as an equivalent direct current (DC) ✓ (2)

$$2.5.3 \quad V_{rms} = \frac{V_{max}}{\sqrt{2}} \checkmark$$

$$V_{rms} = \frac{120}{\sqrt{2}}$$

$$= 60\sqrt{2}\text{V}$$

$$P_{av} = V_{rms}I_{rms} \checkmark$$

(4)



$$= (60\sqrt{2})(1.41) \checkmark$$

$$= 101.82W \checkmark$$

[13]

QUESTION 3

3.1.1 X✓

3.1.2 Change the direction of the magnetic field (turn magnet upside down). (1)
Change the direction of the current (turn the battery around). ✓

3.1.3 Increase the strength of the magnetic field (use stronger magnet). ✓ Increase (2)
the current in the conductor. ✓

Increase the thickness of the magnet to increase the length of the magnetic field.

(Any of the above)

3.2.1 The AC potential difference ✓ which dissipates/produces the same amount of (2)
energy as an equivalent DC potential difference. ✓

3.2.2 AC-slip rings ✓

DC- commutator ✓ (2)

3.2.3 $V_{rms} = \frac{V_{max}}{\sqrt{2}} \checkmark$

$$V_{rms} = \frac{460}{\sqrt{2}}$$

$$= 325.27 V$$

3.2.4 $I_{rms} = \frac{V_{rms}}{R} \checkmark$

$$= \frac{325,27 \checkmark}{40 \checkmark}$$

$$= 8,13A \checkmark$$

(4)

[11]

QUESTION 4

4.1 Slip-rings✓ (1)

4.2 B✓ (1)

4.3 $V_{rms} = \frac{V_{max}}{\sqrt{2}} \checkmark$ (3)

$$V_{rms} = \frac{320}{\sqrt{2}} \checkmark$$

$$= 220.62 \text{ V} \checkmark$$

4.4.1 $P_{av} = \frac{V_{rms}^2}{R} \checkmark$ (3)

$$= \frac{(220.62)^2}{40} \checkmark$$

$$= 1216.83 \text{ W} \checkmark$$

4.4.2 $I_{max} = \frac{V_{max}}{R} \checkmark$ (4)

$$= \frac{320}{40} \checkmark \checkmark$$

$$= 7.8 \text{ A} \checkmark$$



[12]

QUESTION 5

5.1.1 From electrical energy to mechanical energy. $\checkmark$ (1)

5.1.2 DC motor. $\checkmark$ external power source (1)

5.1.3 (carbon) brush $\checkmark \checkmark$ (2)

5.1.4 It reverses the direction of the current in the coil after each half-cycle $\checkmark$ (1)

5.1.5 Increases. $\checkmark$ The current increases $\checkmark$ (2)

5.2.1 The rms potential difference is the AC potential difference which dissipates/produces the same amount of energy as an equivalent DC potential difference $\checkmark \checkmark$ (2)

5.2.2 $V_{rms} = \frac{V_{max}}{\sqrt{2}} \checkmark$ (3)

$$200 = \frac{V_{max}}{\sqrt{2}} \checkmark$$

$$V_{max} = 282.82 \text{ V} \checkmark$$

[12]

PHOTOELECTRIC EFFECT: SOLUTIONS

QUESTION 1

- 1.1 D ✓✓ (2)
 1.2 C ✓✓ (2)
 1.3 D ✓✓ (2)
 1.4 A ✓✓ (2)
 1.5 D ✓✓ (2)
 1.6 A ✓✓ (2)
[12]

QUESTION 2

- 2.1. Metal (cathode)/ work function/threshold frequency✓ (1)
 1 (maximum) kinetic energy✓ (1)
 2 Photoelectric effect✓ (1)
 2.2 The minimum energy that an electron in the metal needs to be emitted from the metal surface. ✓✓ (2)
 2.4. $W_0 = hf_0$ ✓
 1 $= (6.63 \times 10^{-34})(1.75 \times 10^{15})$ ✓
 $= 1.16 \times 10^{-18} \text{ J}$ ✓ (3)
 2.4. $E = W_0 + E_{K(\text{MAX})}$ ✓
 2 $(6.63 \times 10^{-34})f = 1.16 \times 10^{-18} + \frac{1}{2}(9.11 \times 10^{-31})(5.23 \times 10^5)^2$ ✓
 $f = 1.94 \times 10^{-19} \text{ Hz}$ ✓ (4)
 2.5 Increases✓
 The number of photons per unit time increases✓ when the intensity of the light increase. Therefore, the number of photo-electrons per unit time increases. ✓ (3)

[15]

QUESTION 3

- 3.1 Light has a particle nature/is quantized✓ (1)
 3.2 The minimum energy (of incident photons) that can eject electrons from a metal/surface. ✓✓ (2)
 3.3 $E = W_0 + E_{K(\text{MAX})}$ ✓
 $(6.63 \times 10^{-34})(5.96 \times 10^{14}) = 3.42 \times 10^{-19} + E_{K(\text{max})}$ ✓✓
 $E_{K(\text{max})} = 5.30 \times 10^{-20} \text{ J}$ ✓ (4)
 3.4 $q = I\Delta t$
 $= (0.012)(10)$ ✓
 $= 0.12 \text{ C}$
 $n = \frac{Q}{e}$
 $n = \frac{0.12}{1.6 \times 10^{-19}}$ ✓
 $n = 7.5 \times 10^{17} \text{ (electrons)}$ (4)

number of photons = $n = 7,5 \times 10^{17} \checkmark \checkmark$

3.5 Increases $\checkmark$

More photons strike the surface of the metal per unit time/ at a higher rate $\checkmark$
hence more (photo) electrons ejected per unit time $\checkmark$ (resulting in increased current).

(3)

[14]

QUESTION 4

4.1 The minimum energy (of incident photons) that can eject electrons from a metal/surface. $\checkmark \checkmark$

(1)

4.2 $1 \checkmark \checkmark$

4.3. $E_{k(max)} = \frac{1}{2} m v_{max}^2 \checkmark$

1

$$2,99 \times 10^{-19} = \left(\frac{1}{2}\right) (9.11 \times 10^{-31}) v_{max}^2 \checkmark$$

$$v_{max}^2 = 8,10 \times 10^5 \text{ m.s}^{-1} \checkmark$$

(3)

4.3. $E = W_0 + E_{K(MAX)} \checkmark$

2

$$E = (3.68 \times 10^{-19}) + 2,99 \times 10^{-19} \checkmark \checkmark$$

$$E = 6,67 \times 10^{-19} \text{ J} \checkmark$$

(4)

4.4 Remain the same $\checkmark$

The energy of the incident photon is not changing $\checkmark$

(2)

[13]

QUESTION 5

5.1 The minimum energy (of incident photons) that can eject electrons from a metal/surface. $\checkmark \checkmark$

(2)

5.2 $E = \frac{hc}{\lambda} \checkmark$

$$E = \frac{(6,63 \times 10^{-34})(3 \times 10^8)}{400 \times 10^{-9}} \checkmark$$

$$E = 4,97 \times 10^{-19} \text{ J} \checkmark$$

(3)

5.3 $E = W_0 + E_{K(MAX)} \checkmark$

$$4,97 \times 10^{-19} \checkmark = (2,46 \times 10^{-19}) + \frac{1}{2} (9.11 \times 10^{-31}) v_{max}^2 \checkmark$$

$$v_{(max)} = 742322,57 \text{ m.s}^{-1} \checkmark$$

(4)

5.4 No $\checkmark$

The work function of platinum is higher than the energy of the photon $\checkmark$

(2)

[11]

QUESTION 6

6.1.1 $E = hf \checkmark$

(4)

$$E = (6.63 \times 10^{-34})(2.8 \times 10^{16}) \checkmark$$

$$E = 1.86 \times 10^{-17} \text{ J } \checkmark$$

$E > W_0$ electrons will be ejected $\checkmark$

6.1.2

$$F = \frac{kQ_1Q_2}{r^2} \checkmark$$

$$0,027 = \frac{(9 \times 10^9)(5.4 \times 10^{-6})Q_2}{(0.1)^2} \checkmark \checkmark$$

$$Q_2 = 5.56 \times 10^{-9} \text{ C}$$

$$n = \frac{Q}{e} \checkmark$$

$$n = \frac{5.56 \times 10^{-9}}{1.6 \times 10^{-19}} \checkmark$$

$$n = 3.47 \times 10^{10} \text{ electrons}$$

$$\text{number of photons} = n = 3.47 \times 10^{10} \checkmark$$

6.2.1 Absorption $\checkmark$

6.2.2 Continuous spectrum of white light, with dark lines replacing frequency. $\checkmark \checkmark$

6.2.3 Diagram B $\checkmark$

(6)

(1)

(2)

(1)

[14]

ORGANIC MOLECULES: SOLUTIONS MULTIPLE CHOICE QUESTIONS

1.1. A $\checkmark \checkmark$

1.2. B $\checkmark \checkmark$

1.3. C $\checkmark \checkmark$

1.4. B $\checkmark \checkmark$

1.5. B $\checkmark \checkmark$

1.6. D $\checkmark \checkmark$

1.7. D $\checkmark \checkmark$

1.8. C $\checkmark \checkmark$

1.9. A $\checkmark \checkmark$

1.10. C $\checkmark \checkmark$

(2)

(2)

(2)

(2)

(2)

(2)

(2)

(2)

(2)

(2)

LONG QUESTIONS QUESTION 1

1.1.1 D $\checkmark$

1.1.2 A $\checkmark$

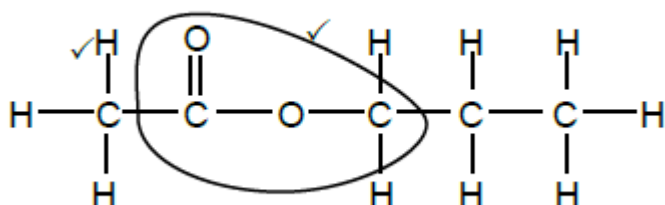
1.1.3 E $\checkmark$

(1)

(1)

(1)

- 1.2.1 Butanal ✓✓ (2)
 1.2.2 4,4-dimethylpent-2-yne ✓✓✓ (3)
 1.3.1 Compounds with the same molecular formula, ✓ but different functional groups/homologous series. ✓ (2)
 1.3.2 A and C ✓ (1)
 1.4.1 H_2SO_4 /Sulphuric acid ✓ (1)
 1.4.2 Esterification/Condensation ✓ (1)
 1.4.3

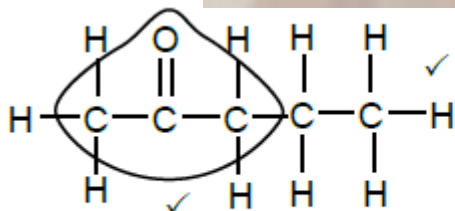


- 1.4.4 Propan-1-ol ✓✓ (2)

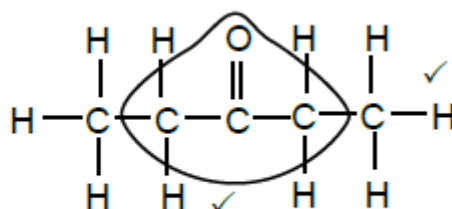


QUESTION 2

- 2.1. Organic compounds that consist of hydrogen and carbon only. ✓✓ (2)
 2.2.1 C and E ✓ (1)
 2.2.2 D and H ✓✓ (2)
 2.2.3 A ✓ (1)
 2.3.1

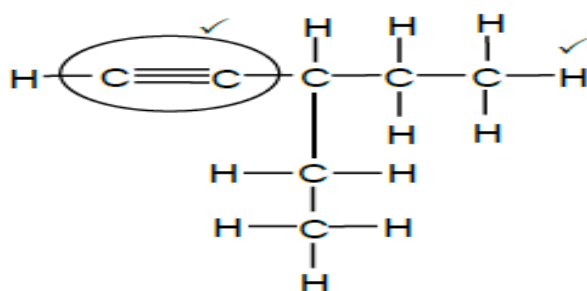


OR/OF



- 2.3.2 $\text{C}_n\text{H}_{2n+2}$ ✓ (2)

- 2.3.3



- 2.4.1 3-ethylhex-3-ene ✓✓✓ (3)
 2.4.2 2,5-dichloro-2,4-dimethylhexane ✓✓✓ (3)
 2.4.3 2,2-dimethylpropanal ✓ (2)
 2.5 $\text{C}_7\text{H}_{16} + 11\text{O}_2 \rightarrow 7\text{CO}_2 + 8\text{H}_2\text{O}$ ✓✓✓ (3)

[22]

QUESTION 3

3.1 A bond or an atom or a group of atoms that determine(s) the physical and chemical properties of a group of organic compounds. ✓✓ (2)

3.2.1 E✓ (1)

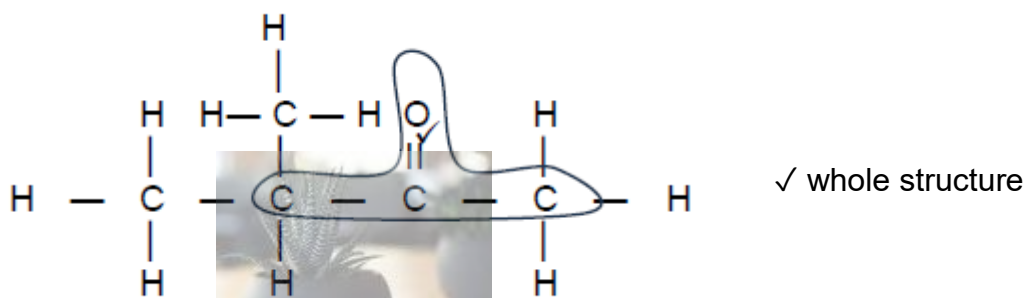
3.2.2 A✓ (1)

3.2.3 C✓ (1)

3.3 EQUAL TO✓

Compound **E** and ethyl methanoate are functional isomers / structural isomers / have the same molecular formula / same number and type of atoms/same number of C, H and O atoms. ✓✓ (3)

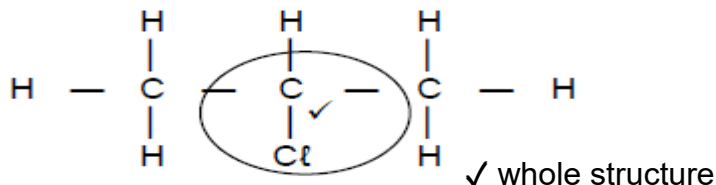
3.4.1



3.4.2 Propanoic acid ✓✓ (2)

3.4.3 4-methylhex-2-yne ✓✓✓ (3)

3.5



3.6 $C_7H_{12} + 10 O_2 \rightarrow 7 CO_2 + 6 H_2O$ ✓ Bal. ✓

(2)

(3)

[20]

QUESTION 4

4.1. Compounds with one or more multiple bonds between C atoms in the hydrocarbon chain ✓✓ (2)

4.2.1 D✓ (1)

4.2.2 2,4-dimethylhexane ✓✓✓ (3)

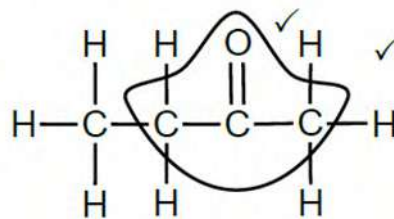
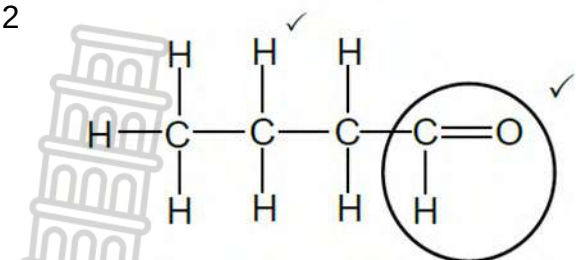
4.2.3 Propan-2-ol ✓✓ (2)

4.2.4 Hept-1-ene ✓✓ (2)

4.2.5 $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$ ✓ Balancing ✓ (3)

4.3.1 Compounds with the same molecular formula but different functional groups/homologous series ✓✓ (2)

4.3.2



(4)

4.4

	C	H	O
Mass	1,09	0,18	2-(1,09 +0,18) =0,73✓
Moles	$n = \frac{m}{M}$ $= \frac{1,09}{12} \checkmark$ =0,0908	$n = \frac{m}{M}$ $= \frac{0,18}{1} \checkmark$ =0,18	$n = \frac{m}{M}$ $= \frac{0,73}{16} \checkmark$ =0,046
Simplest ratio	2	4	1
Empirical formula	C ₂ H ₄ O✓		
M(C ₂ H ₄ O) x n = 88 (g.mol ⁻¹) 4n = 88 n = 2			
Molecular formula of compound X: C ₄ H ₈ O ₂ ✓			

(6)

[25]

QUESTION 5

5.1 The pressure exerted by a vapour at equilibrium with its liquid in a closed system. $\checkmark \checkmark$ (2)

5.2.1 146 (kPa) $\checkmark \checkmark$ (1)

5.2.2 Comparing compound C/2,2-dimethylpropane with compounds A/pentane and B/2-methylbutane

- Structure: Compound C is more branched than compounds A and B/Shorter chain length/most compact most spherical/smallest surface area (over which intermolecular forces act). $\checkmark$

- Intermolecular forces: Compound C has weaker/less intermolecular forces/Van der Waals forces/London forces than A and B. $\checkmark$

- Energy: Lesser energy needed to overcome or break intermolecular forces/Van der Waals force in compound C than A and B. $\checkmark$ (3)

5.3.1 E/butanal $\checkmark$ (1)

5.3.2 • Compound D/Propanoic acid has hydrogen bonding (dipole-dipole and London forces) between molecules. $\checkmark$

- Compound E/Butanal has dipole-dipole forces (and London forces) between molecules. ✓
- Intermolecular forces between molecules of compound D/propanoic acid are stronger than intermolecular forces between molecules of compound E/butanal. ✓
- More energy is needed to overcome/break intermolecular forces between molecules of compound D/propanoic acid than in compound E/butanal ✓

[11]

QUESTION 6

6.1 The temperature at which the vapour pressure of a substance equals atmospheric/external pressure. ✓✓ (2)

6.2 C ✓ (1)

6.3 A/ $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Cl}$ /1-chlorobutane

- Structure: Longer chain length/larger surface area (over which intermolecular forces act). ✓
- Intermolecular forces: Stronger/more intermolecular forces/Van der Waals forces/London forces/dipole-dipole forces. ✓
- Energy: More energy needed to overcome or break intermolecular forces/Van der Waals forces/dipole-dipole forces. ✓

OR

B/ $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{Cl}$ /1-chloro-2-methylpropane

- Structure: Shorter chain length / branched / compact / more spherical / smaller surface area (over which intermolecular forces act). ✓
- Intermolecular forces: Weaker/less intermolecular forces/Van der Waals forces/London forces/ dipole-dipole forces. ✓
- Energy: Less energy needed to overcome or break intermolecular forces/Van der Waals forces/dipole-dipole forces. ✓

6.4.1 75 (°C) ✓✓ (3)

6.4.2 • Intermolecular forces: C ($\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ /butanol) has stronger intermolecular forces than D ($\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$ /butanal). ✓ (2)

- Energy: More energy needed to overcome or break intermolecular forces. ✓

Accept: Boiling point of C will be more (in relation to C and D/118°C vs 75°C).

6.5 Decreases ✓ (1)

[10]

QUESTION 7

7.1.1 The temperature at which the vapour pressure of a substance / liquid equals the atmospheric pressure ✓✓ (2)

7.1.2 All are primary alcohols ✓ (1)

7.1.3 London forces/dispersion forces/induced-dipole forces ✓ (1)

7.1.4 Pentan-1-ol ✓✓ (2)

7.2.1 Compound C/propanoic acid ✓ (1)

7.2.2 Compound A/butanone has dipole-dipole forces ✓ (and London forces / dispersion forces/induced-dipole forces)

Compound B/butan-1-ol and C/propanoic acid has hydrogen bonds ✓ (and London forces/dispersion forces/induced-dipole forces)

Compound B/butan-1-ol has one site for hydrogen bonding and C/propanoic acid has two sites for hydrogen bonding ✓

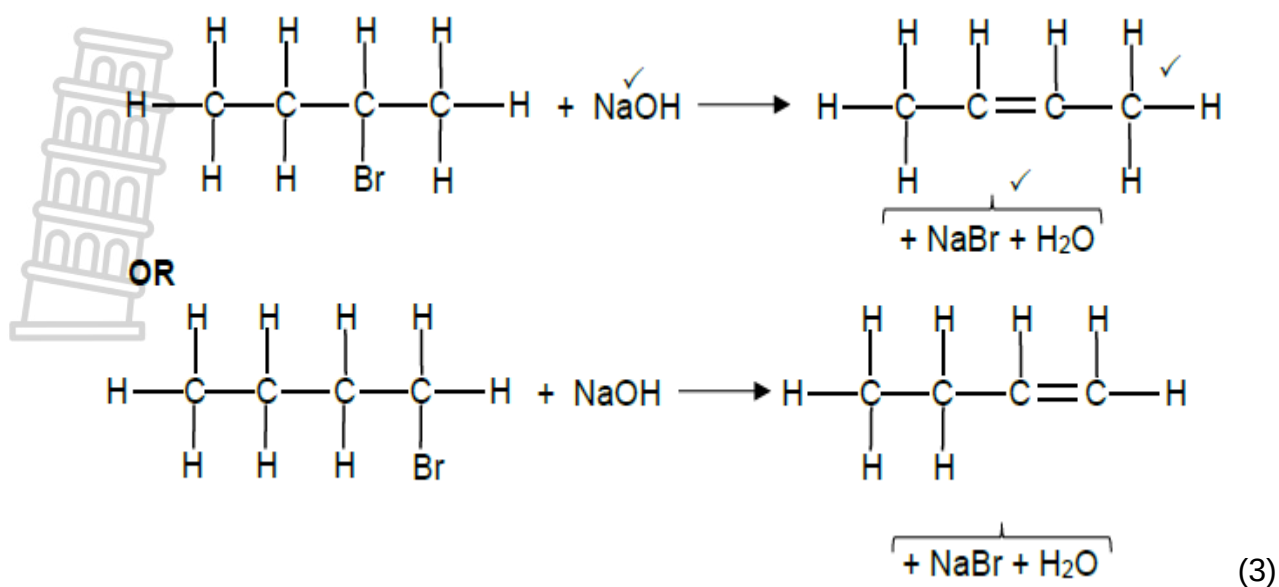
Strength of the intermolecular forces increases from compound A / butanone to compound B / butan-1-ol to compound C / propanoic acid ✓

More energy is needed to overcome the intermolecular forces in compound C / propanoic acid than compounds A/ butanone and B/butan-1-ol ✓ (5)

[12]

QUESTION 8

- 8.1. The temperature at which the vapour pressure of a liquid equals the atmospheric pressure ✓✓ (2)
- 8.2.1 Molecular size/ Surface area / Chain length✓ (1)
- 8.2.2 Functional group / Homologous series✓ (1)
- 8.3 London forces / induced dipole forces / dispersion forces ✓ (1)
- 8.4 129 °C ✓ (1)
- 8.5
- 2-methylbutan-1-ol has a larger molar mass/molecular size than butan-1-ol ✓
 - London forces/induced dipole forces/dispersion forces of 2-methylbutan-1-ol is stronger than that butan-1ol ✓
 - The boiling point will higher than that of butan-1-ol
 - 2-methyl butan-1-ol has a shorter chain length than pentan-1-ol✓
 - London forces of 2-methyl butan-1-ol is weaker than that of pentan-1-ol ✓
 - The boiling point will be lower than that of pentan-1-ol (4)
- 8.6.1 The pressure exerted by a vapour at equilibrium with its liquid in a closed system. ✓✓ (2)
- 8.6.2 Q ✓ (1)
- 8.6.3
- Propan-1-ol has hydrogen bonds ✓(and London forces/induced dipole forces/dispersion forces
 - Propanal has dipole-dipole forces ✓(and London/induced dipole forces/dispersion forces (4)
 - Hydrogen bonds are stronger than dipole-dipole forces ✓
 - The stronger the intermolecular forces the lower the vapour pressure



[17]

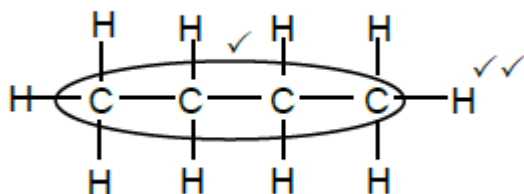
QUESTION 9

9.1. The chemical process/reaction in which longer chain hydrocarbon/alkane molecules/are broken down to shorter (more useful) molecules. ✓✓ (2)

9.2 Primary ✓

The halogen/bromine/functional group (-X) is bonded to a C atom that is bonded to one other C atom.✓ (2)

9.3.1



(3)

9.3.2 C_8H_{18} ✓

9.4.1 Br_2 /Bromine✓

9.4.2 Substitution ✓

9.4.3 UV/(Sun)light/Heat ✓

9.5 Dehydrohalogenation/Dehydrobromination✓

(1)

(1)

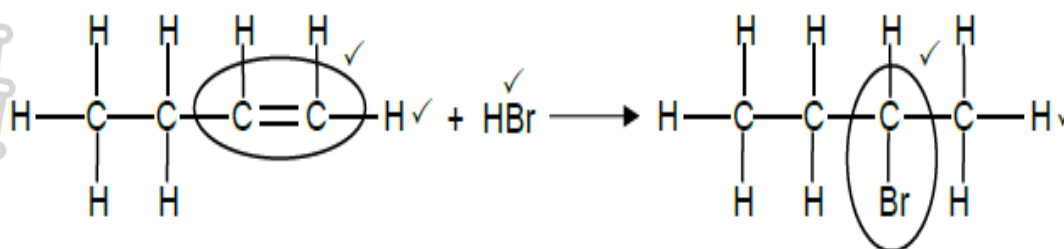
(1)

(1)

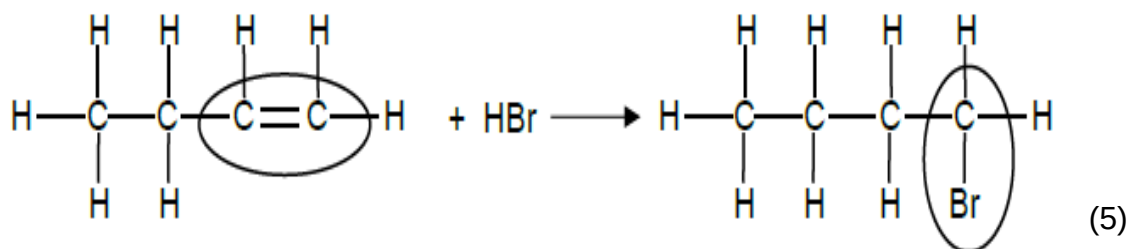
(1)



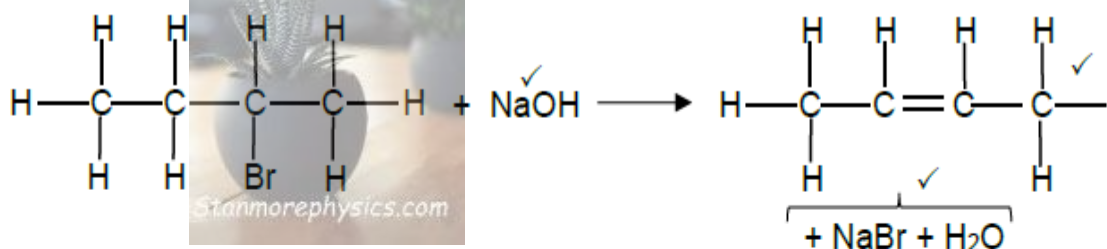
9.6.1



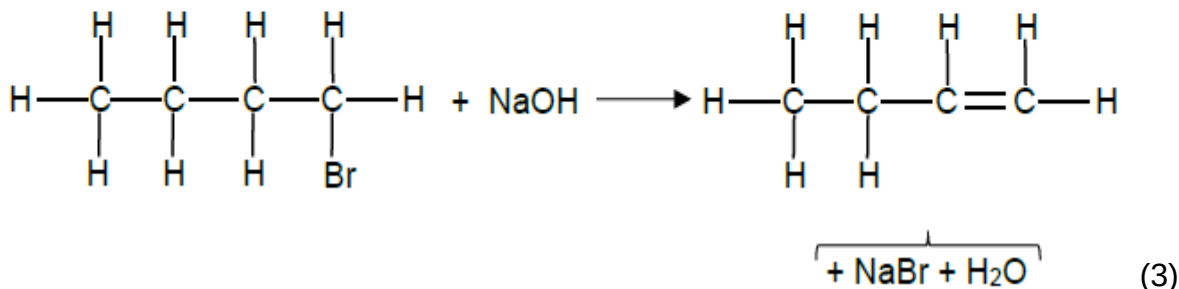
OR



9.6.2



OR



9.6.3 But-2-ene /but-1-ene ✓✓

(2)

[22]

QUESTION 10

10.1. Concentrated) sulphuric acid/H₂SO₄(aq) ✓

(1)

1

10.1. Esterification / Condensation ✓

(1)

2

10.1. • Alcohol/methanol/reactant is flammable/catches fire easily. ✓

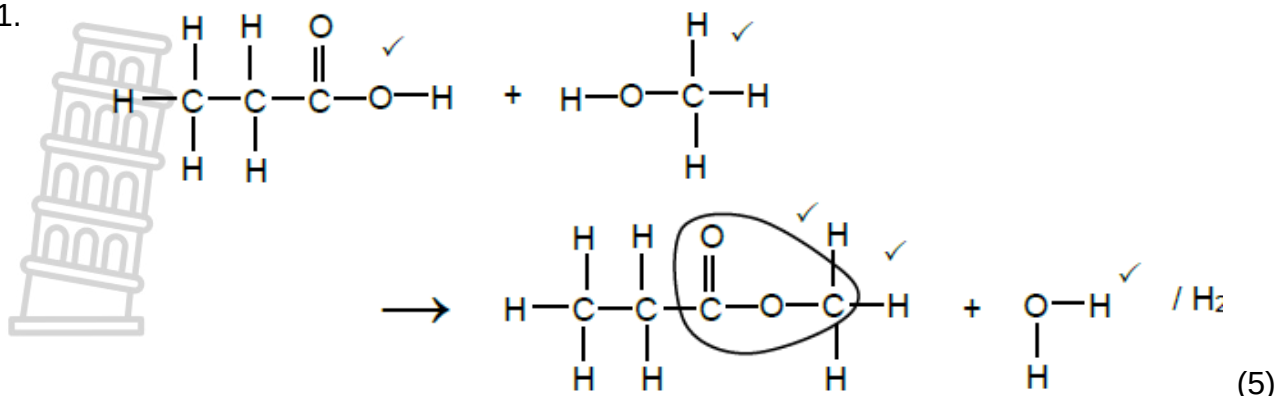
3.

• To heat evenly/A steady/controlled/gradual increase in temperature. ✓

(2)



10.1.
4



10.1. Methyl propanoate ✓✓

5 (2)

10.2. Hydrogen/H₂ ✓

1 (1)

10.2. 3,3-dimethyl✓but-1-ene✓

2 (2)

10.2. elimination **OR** dehydrohalogenation ✓

3 (1)

10.2. H₂SO₄/H₃PO₄ **OR** Sulphuric acid/Phosphoric acid ✓

4 (1)

10.2. 3,3-dimethyl ✓butan-2-ol ✓

5 (2)

10.2. Addition/hydration ✓

6 (1)

10.2. Secondary ✓

7 (1)

[20]

QUESTION 11

11.1 UNSATURATED✓ It contains a double bond between its carbon-carbon atoms in the hydrocarbon chain. ✓

(2)

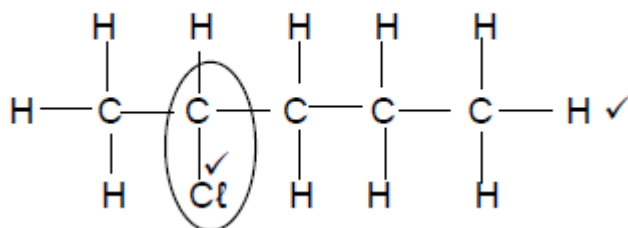
11.2 Substitution/Hydrolysis of a haloalkane✓

(1)

11.3 Elimination/dehydrohalogenation of haloalkanes ✓

(1)

11.4



11.5 Pentan-2-ol ✓✓

(2)

11.6 Dilute strong base/NaOH✓ and mild heat ✓

(2)

11.7 Positional isomers ✓✓

(2)

[12]

QUESTION 12

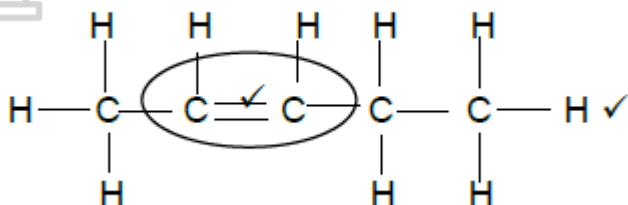
12.1. Hydrolysis ✓ (1)

1
12.1. Pentan-2-ol ✓✓ (2)

2
12.1. Concentrated strong base/ NaOH/ KOH/ LiOH✓ (1)

3
12.1. (2)

4



12.1. Sulphuric acid ✓ (1)

5
12.1. Dehydration ✓ (1)

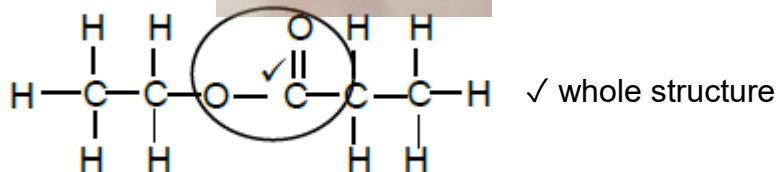
6
12.2. Esterification / Condensation ✓ (1)

1
12.2. Alcohols are flammable✓ (1)

2

12.2.

3



ethyl ✓propanoate ✓

(4)

[14]

REACTION RATE: SOLUTIONS

Question 1

1.1 C ✓✓ (2)

1.2 C ✓✓ (2)

1.3 D ✓✓ (2)

1.4 A ✓✓ (2)

1.5 B ✓✓ (2)

LONG QUESTIONS

[10]

Question 1

1.1 Exothermic ✓ (2)

$\Delta H < 0$ /Energy is released ✓ (2)

1.2 Rate = $-\frac{\Delta m}{\Delta t}$

$$= - \frac{(0,25-2)\sqrt{30}}{30\sqrt{30}} \quad (3)$$

$$= 0,06 \text{ g.s}^{-1}\sqrt{30}$$

1.3 $m(\text{CaCO}_3) = \frac{40}{100} \times 2\sqrt{30} = 0,8 \text{ g}$

$$n = \frac{m}{M} = \frac{0,8}{100}\sqrt{30} = 8 \times 10^{-3} \text{ mol}$$

$$n(\text{CO}_2) = n(\text{CaCO}_3)\sqrt{30} = 8 \times 10^{-3} \text{ mol} \quad (5)$$

$$V(\text{CO}_2) = 8 \times 10^{-3} \times 22,4\sqrt{30} = 0,18 \text{ dm}^3\sqrt{30}$$

1.4 **Any one :**

- Concentration (of acid) $\checkmark$
 - Size/mass of tablet/Identical tablet /Type of tablet. $\checkmark$
 - State of division / Surface area $\checkmark$
- (1)

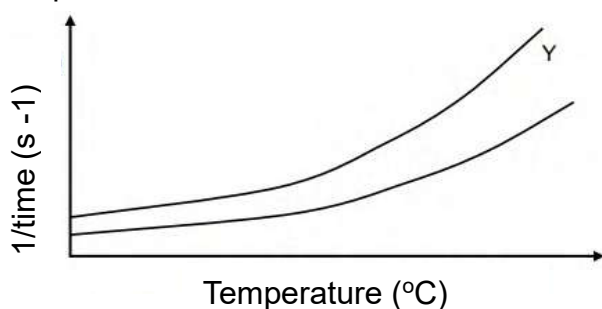
1.5 **Any one:**

- Reaction rate increases with increase in temperature. $\checkmark$
 - Reaction rate decreases with decrease in temperature. $\checkmark$
 - Time taken for reaction decreases when temperature increases. $\checkmark$
- (2)

- 1.6
- Increase in temperature increases the average kinetic energy/molecules move faster. $\checkmark$
 - More molecules have enough/sufficient kinetic energy/More molecules have $E_k > E_a$. $\checkmark$
 - More effective collisions per unit time/second. /Frequency of effective collisions increases. $\checkmark$
- (3)

1.7 **Marking guideline:**

- For each value of temperature, the CURVE Y must be above the given CURVE. $\checkmark$
- CURVE Y must have an increasing rate with an increase in temperature. $\checkmark$



(2)
[18]

Question 2

2.1.1 Exothermic. Energy of products is less than energy of reactants $\checkmark\checkmark$ (2)

2.1.2 Number of particles with enough energy to react. Kinetic energy greater than activation energy $\checkmark$ (1)

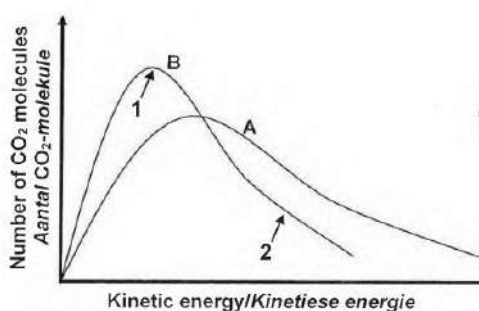
2.1.3 $24,8 - 208,2 = 32,6 \text{ (KJ)}\checkmark\checkmark$ (2)

- 2.2.1 Decrease ✓ (1)
 2.2.2 Remains the same ✓ (1)
 2.2.3 Remains the same ✓ (1)
 2.3.1 Concentration ✓ (1)
 2.3.2 More particles per unit Volume ✓, more effective collision per unit time ✓, higher reaction rate ✓ (3)
 2.3.3 $rate = \frac{\Delta V}{\Delta t} \checkmark 40 = \frac{\Delta v}{(2.6)(60)} \checkmark = 6240 \text{ cm}^3 \quad n = \frac{V}{V_m} = \frac{6240}{27000} \checkmark$
 $n(\text{Al}) = \frac{2}{3}(0.23) \checkmark = 0.15 \text{ mol} \quad 0.15 = \frac{m}{27} \checkmark \quad \% \text{purity} = \frac{4.05}{5}(100) \checkmark$
 $= 81\% \checkmark$ (6)

[18]

Question 3

- 3.1 Change in concentration of reactant or product per (unit) time. ✓✓ (2)
 3.2 Surface area ✓ (1)
 3.3 Higher kinetic energy, higher speed ✓. More molecules with enough energy ✓. More effective collision per unit time ✓. Rate of reaction also increase ✓ (2)
 3.4 (1)
 3.4.1 $n = \frac{m}{M} \checkmark = \frac{5}{84} \checkmark \quad n(\text{CO}_2) = n(\text{MgCO}_3) \checkmark = 0.06 \text{ mol}$
 $0.06 = \frac{m}{44} \checkmark \quad 0.5 \checkmark = \frac{2.64}{\Delta t} \quad \Delta t = 5.28 \text{ min} \checkmark$ (6)
 3.4.2 $n = \frac{V}{V_m} \checkmark \quad 0.06 = \frac{1.5}{V_m} \quad V_m = 25 \text{ dm}^{-3} \checkmark$ (2)
 3.5



(2)
[17]

Question 4

4.1 B ✓ (4)

Catalyst provides an alternative path of lower activation energy✓, more particles with enough energy to react or higher than activation energy✓, more collision per unit time ✓

4.2 Y. ✓✓ (2)

4.3 (2)

4.3.1 0.56dm³ or 560(cm³)✓✓ (2)

4.3.2 $n = \frac{V}{V_m} \checkmark = \frac{560}{24000} \checkmark n(H_2O) = 2n(O_2) \quad n = 2(0.023)\checkmark = (0.046)(18)$
= 0.83g✓ (4)

4.4.1 Zero ✓ (1)

4.4.2 Greater ✓ (1)

4.6 $n = \frac{m}{M} \quad n(O_2) = \frac{0.9}{32} \checkmark = 0,028\text{mol}$
M 32

$n(H_2O_2) = 2n(O_2) = 2(0.028)\checkmark = 0.056$

$$2.1 \times 10^{-3} = \frac{0.056 - 0}{\Delta t} \quad \Delta t = 26.67 \quad (5)$$

[15]

Question 5

5.1 Temperature ✓ (1)

5.2 Change in concentration of reactant or product per (unit) time. ✓✓ (2)

5.3 14 (min) ✓ (1)

5.4.1 Graph B ✓(Experiment 3) has the highest (acid) concentration/more particles/higher number of moles. ✓ (2)

5.4.2 Graph C ✓(Experiment 5) is at highest temperature/more particles with sufficient kinetic energy/HCl is at 35° C ✓ (2)

5.5.1 Speeds up the reaction/Increases the reaction rate/ Provides alternate pathway/Lowers the (net) activation energy. ✓ (2)

5.5.2 Equal to ✓ (1)

5.3 $n(Zn) = \frac{m}{M} = \frac{1.5}{65} \checkmark = 0.023 \text{ mol}$ (4)

$$\text{Rate} = -\frac{\Delta n}{\Delta t} = -\frac{(0-0.023)}{(14-0)} \checkmark \checkmark = 1,65 \times 10^{-3} \text{ mol} \cdot \text{min}^{-1} \checkmark$$

[15]

Question 6

6.1.1 Temperature ✓ (1)

6.1.2 Reaction rate ✓ (1)

6.2

- Larger surface area. ✓
- More particles with enough energy and collide with correct orientation. ✓

More effective collisions per unit time. ✓ (3)

6.3 C ✓

Exp 1 and 2

- Reaction in Exp 1 is faster than Exp 2 due to higher concentration of the acid. ✓
- The gradient in Exp 1 is steeper than in Exp 2 ✓

Exp 1,3 and 4

- Reaction in Exp 3 is faster than Exp 1 due to higher temperature. ✓
 - Reaction in Exp 4 is faster than Exp 1 due to higher temperature/larger surface area. ✓
- Therefore, the gradient of graphs of Exp 3 and 4 is steeper than in Exp 1 ✓

(6)

6.4

$$n(\text{CO}_2) = \frac{V}{V_m} = \frac{4,5}{25,7} \checkmark = 0,18 \text{ mol}$$

$$V_m = 25,7$$

$$n(\text{CaCO}_3) = n(\text{CO}_2) = 0,18 \text{ mol} \checkmark$$

$$n(\text{CaCO}_3) = \frac{m}{M}$$

AA

(5)

Question 7

7.1 Change in concentration of products / reactants per unit time ✓✓ (2)

7.2.1 Temperature ✓ (1)

7.2.2 Rate of reaction / volume of gas formed per unit time ✓ (1)

7.3 High temp / high concentration ✓ more effective collision/more molecules with enough energy, ✓ more collision per unit time ✓ (4)

7.4 Exp 1 is faster than exp 2 due higher concentration ✓ steeper gradient ✓ (4)
Exp 4 faster than exp 1 due to higher temp ✓✓

Final C

$$7.5 \quad n = \frac{V}{V_m} = \frac{4.5}{25.7} \checkmark = 0.18 \text{ mol}$$

$$N(\text{CO}_2) = 0.18 \text{ mol} \checkmark \quad 0.18 = \frac{m}{100} \checkmark \quad m = 18\text{g}$$

$$M = 28 - 18 = 7.00\text{g} \checkmark$$

(5)

DOPPLER EFFECT: SOLUTIONS

MULTIPLE CHOICE QUESTIONS

- | | | |
|---|---|-----|
| 1 | A | (2) |
| 2 | B | (2) |
| 3 | A | (2) |
| 4 | D | (2) |
| 5 | C | (2) |

QUESTION 1

1.1.1 Radar cameras-used identify/scanning over speeding cars. ✓ (1)

1.1.2 Burglar alarms. ✓ (1)

1.1.3 Sonar technology– used to locate objects under water. ✓ (1)

1.2 Directly proportional✓ (1)

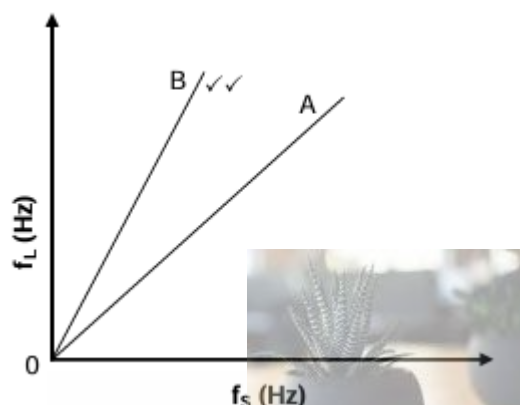
1.3 $f_l = \left(\frac{v \pm v_L}{v \pm v_S} \right) f_s$ ✓ (5)

$$\frac{f_L}{f_s} = \left(\frac{v \pm v_L}{v \pm v_S} \right)$$

$$1,06 \checkmark \checkmark = \frac{340 + v_L}{340} \checkmark$$

$$v_L = 20,4 \text{ m.s}^{-1} \checkmark$$

1.4 (2)



- Graph is a straight line starting from origin
- Gradient of B is greater than gradient of A

QUESTION 2

2.1 As the ambulance is moving away from the scene/detector, the wavelength become longer resulting in less waves reaching detector per unit time hence the frequency decreases. (2)

2.2 $f_l = \left(\frac{v \pm v_L}{v \pm v_S} \right) f_s$ ✓ (5)

$$0,9 f_s \checkmark = \left(\frac{340}{340 + v_S} \right) f_s \checkmark$$

$$340 = 306 + v_S \checkmark$$

$$v_S = 37,78 \text{ m.s}^{-1} \checkmark$$

2.3 (2)

2.3.1 Red shift- shift in spectra of a distant galaxies towards longer wavelengths, towards the red end of the spectrum. ✓✓

2.3.2 The shift is to a longer wavelength (lower frequency), therefore the star is moving away from the earth. ✓ (1)

2.3.3 A greater shift shows that the distant star is moving away at a greater speed than a nearby star. ✓✓ (2)

QUESTION 3

3.1 Ambulance approaching : (6)

$$f_l = \left(\frac{v \pm v_L}{v \pm v_S} \right) f_s \checkmark$$

$$450 = \frac{340 + 0}{340 - v_S} f_s$$

$$450(340-v_s) = 340f_s \dots\dots\dots(i) \checkmark$$

Ambulance moving away

$$385 = \frac{340-0}{340+v_s} f_s$$

$$385(340+v_s) = 340f_s \dots\dots\dots(ii) \checkmark$$

$$450(340-v_s) = 385(340+v_s) \checkmark$$

$$v_s = 26.46 \text{ m.s}^{-1} \checkmark$$

$$3.2 \quad 450(340-v_s) = 340f_s \quad (2)$$

$$450(340-26.46) = 340f_s$$

$$f_s = 414.98 \text{ Hz}$$

$$3.3 \quad 414.98 \text{ Hz} \quad (1)$$

QUESTION 4

4.1 Ambulance $\checkmark$

(1)

4.2 fire engine $\checkmark$

(1)

4.3 (Fire engine)

(6)

$$f_L = \frac{v \pm v_L}{v \pm v_s} f_s \checkmark$$

$$850 \checkmark = \frac{v+0}{v+20} \checkmark (900) \checkmark$$

$$v = 340 \text{ m.s}^{-1}$$



(ambulance)

$$1030 = \frac{340}{340-v_s} (920) \checkmark$$

$$v_s = 36,31 \text{ m.s}^{-1} \checkmark$$

4.4 When a distant star emits light, its spectrum can be observed on earth $\checkmark$. The spectral lines for certain elements do not correspond to that of the same elements when the light source is stationary $\checkmark$. The shift in the spectral lines (towards red) $\checkmark$ implies that the frequency observed is lower than actual frequency. Hence the star is moving away from the earth or earth is expanding $\checkmark$. (4)

QUESTION 5

5.1 Doppler effect $\checkmark$. It is the change in frequency (or pitch) of the sound detected by a listener because the sound source and the listener have different velocities relative to the medium of sound propagation $\checkmark \checkmark$. (3)

$$5.2 \quad \lambda = \frac{v}{f} \checkmark \quad (3)$$

$$\lambda = \frac{340}{30\,000} \checkmark$$

$$\lambda = 0,0113 \text{ m} \checkmark$$

5.3 Increases (1)

- 5.4 Incident waves Reflected waves (6)
- $$f_L = \frac{v \pm v_L}{v \pm v_s} f_s \checkmark$$
- $$29\,500 \checkmark = \left(\frac{340}{340+v}\right) \left(\frac{340-v}{340}\right) (30\,000) \checkmark$$
- $$f_L = \frac{340-v_L}{340} \checkmark (30\,000) \checkmark$$
- $$v = 2,86 \text{ m.s}^{-1} \checkmark (\text{away from the device})$$

QUESTION 6

- 6.1 The change in frequency (or pitch) of the sound detected by a listener because the sound source and the listener have different velocities relative to the medium of sound propagation. ✓✓ (2)
- 6.2 $\lambda = \frac{v}{f} \checkmark$ (3)
- $$\lambda = \frac{340}{5000} \checkmark$$
- $$\lambda = 0,068 \text{ m} \checkmark$$
- 6.3 Shift 1 Shift 2 (6)
- $$f_L = \frac{v \pm v_L}{v \pm v_s} f_s \checkmark$$
- $$5104 \checkmark = \left(\frac{340}{340-v}\right) \left(\frac{340+v}{340}\right) (5\,000) \checkmark$$
- $$f_L = \frac{340+v}{340} \checkmark (5\,000) \checkmark$$
- $$v = 3,46 \text{ m.s}^{-1} \checkmark \text{ towards the source}$$
- 6.4 To measure heartbeat of the unborn foetus in the womb. (2)
- To measure blood flow rate. ✓✓

QUESTION 7

- 7.1 1,25 or $1 \frac{1}{4}$ ✓ (1)
- 7.2 $14 \times 10^{-4} \text{ s} \checkmark \checkmark$ (2)
- 7.3 $f = \frac{1}{T} \checkmark$ (3)
- $$f = \frac{1}{14 \times 10^{-4}} \checkmark$$
- $$f = 714,29 \text{ Hz} \checkmark$$
- 7.4 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s \checkmark$ (5)
- $$(714,29) \checkmark = \left(\frac{340}{340 - v_s}\right) \checkmark (600) \checkmark$$
- $$v_s = 54,40 \text{ m.s}^{-1} \checkmark (\text{accept } 54,28 \text{ to } 54,40)$$

QUESTION 8

- 8.1 Away from ✓. Observed frequency lower. ✓ (2)
- 8.2 $v = f\lambda \checkmark$ (3)
- $$340 = f (0,34) \checkmark$$
- $$f = 1\,000 \text{ Hz} \checkmark$$
- 8.3 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s \checkmark$ Distance = $v\Delta t$ (6)

$$950 \checkmark = \frac{340 - v_L}{340 + 0} \checkmark (1000) \checkmark$$

$$v_L = 17 \text{ m.s}^{-1}$$

$$\text{Distance} = (17)(10) \checkmark$$

$$\text{Distance} = 170 \text{ m} \checkmark$$

QUESTION 9

9.1 (Doppler) blood flow meter ✓ (1)

9.2 $f_L = 954,3 + (954,3 \times \frac{3,25}{100}) \checkmark$ (2)

$$f_L = 985,31 \text{ Hz} \checkmark$$

9.3 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s \checkmark$ (4)

$$985,31 \checkmark = \frac{v + 0}{v - 10,6} \checkmark (954,3) \checkmark$$

$$v = 336,80 \text{ m.s}^{-1} \checkmark$$

9.4 Decreases ✓ (1)

9.5 For a constant velocity or speed of sound, if the frequency increases, then the wavelength decreases. ✓✓ (2)

QUESTION 10

10.1 $\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$ OR $v = \frac{d}{t} = \frac{300}{10} \checkmark = 30 \text{ m.s}^{-1} \checkmark$ (2)

$$300 = v_i (10) \checkmark$$

$$v_i = 30 \text{ m.s}^{-1} \checkmark$$

10.2 The change in frequency (or pitch) (of the sound) detected by a listener because the source and the listener have different velocities relative to the medium of sound propagation. (2)

10.3 Car/source (just) passes observer. (1)

10.4 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s \checkmark$ (4)

$$932 \checkmark = \frac{340}{340 - 30} f_s \checkmark$$

$$\therefore f_s = 849,76 \text{ Hz} \checkmark$$

10.5 **ANY TWO:** Doppler / Blood flow meter/Measuring the heartbeat of a fetus/Radar/Sonar/Used to determine whether stars are receding or approaching earth. ✓✓ (2)

ACIDS AND BASE: SOLUTIONS

MULTIPLE CHOICE QUESTIONS

1.1. D ✓✓

1.2. D ✓✓

- 1.3. B✓✓
 1.4. B✓✓
 1.5. D✓✓
 1.6. C✓✓

(12)

QUESTION 1

1.1. An acid that can donate 2 (two) protons per molecule. ✓✓

(2)

1.2. 1.2.1. H_3O^+ ✓hydronium ion✓

(2)

1.2.2. SO_4^{2-} ✓✓

(2)

1.2.3. OH^- ✓

(1)

1.3. 1.3.1. $\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$ ✓ ✓Bal

(3)

1.3.2. $c = \frac{n}{V}$ ✓

(3)

$n = (0,5)(1)$ ✓

$n = 0,5\text{mol}$ ✓

1.3.3. $\text{NaOH} : \text{HCl}$
 1:1

(1)

$\therefore n = 0,5\text{mol}$ ✓

1.3.4. HCl ✓

(1)

1.3.5. Initial n $\text{HCl} = 0,5\text{mol}$
 $\text{NaOH } n = 0,06\text{mol}$

(6)

$\text{HCl excess} = 0,5 - 0,06 = 0,44\text{mol}$ ✓

$\text{pH} = -\log[\text{H}_3\text{O}^+]$ ✓

$\text{pH} = -\log 0,44$ ✓

$\text{pH} = 0,36$ ✓

Question 2

2.1. A solution with a known concentration. ✓✓

(2)

2.2.1. A = Pipette ✓

(1)

2.2.2. B = Funnel ✓

(1)

2.3. Because the first trial is discarded. ✓/

(1)

2.4. $\frac{n_a}{n_b} = \frac{c_a V_a}{c_b V_b}$ ✓

(4)

$\frac{C_a \times 25}{0,2 \times 14,25} = \frac{1}{2}$ ✓✓

$0,2 \times 14,25$

$C_a = 0,228\text{mol} \cdot \text{dm}^{-3}$ ✓

2.5. 2.5.1. H_2SO_4 ionises completely ✓ in solution and forms a high concentration of H_3O^+ ✓

(2)

2.5.2. a) H_2SO_4 ✓

(2)

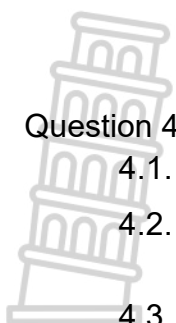
- b) SO_4^{2-} ✓
- 2.5.3. Ampholyte ✓ (1)
- 2.5.4. H_2O ✓ (1)
- 2.6. 2.6.1. A substance that produces hydroxide ions in solution. ✓✓ (2)
- 2.6.2. CaSO_4 ✓ (1)
- 2.6.3. Water ✓ (1)

Question 3

- 3.1. 3.1.1. HSO_4^- ✓ (do not accept : hydrogen sulphate ion) (1)
- 3.1.2. CN^- ✓ (1)
- 3.2. 3.2.1. $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O} + 2\text{HCl} \rightarrow 2\text{NaCl} + 11\text{H}_2\text{O} + \text{CO}_2$ ✓ ✓ bal (3)
- 3.2.2. Methyl orange ✓ (1)
- 3.2.3. Strong acid is titrated with a weak base ✓✓ / the equivalence point is in the pH range (3 – 4,4) / Low pH / Acidic solution after titration end point. Any ONE answer will be correct (2)
- 3.2.4. Red to Yellow ✓ (1)
- 3.2.5.

Option 1: $c\text{HCl} = \frac{n}{V} \checkmark$ $= 0,1 \times \frac{24,8}{1000}$ $= 2,48 \times 10^{-3} \text{ mol HCl} \checkmark$ 1 mol Na_2CO_3 reacts with 2 mol HCl $n(\text{Na}_2\text{CO}_3)$ in 500 cm^3: ✓ $= \frac{2,48 \times 10^{-3}}{2} \times 500/25 \checkmark$ $= 2,48 \times 10^{-3} \text{ mol Na}_2\text{CO}_3$ $n = Mm$ $m = nM$ $= 2,48 \times 10^{-3} \times 286 \text{ g mol}^{-1}$ $= 7,092 \text{ g} \checkmark$	Option 2 $c_a V_a = n_a$ $C_b V_b = n_b$ $(0,1)(24,5 \times 10^{-3}) = 2$ $C_b (25 \times 10^{-3}) = 1$ $C_b = 0,0496 \text{ mol} \cdot \text{dm}^{-3} \checkmark$ $C = Vn$ $n = (0,0496)(0,5) \checkmark$ $= 0,0248 \text{ mol Na}_2\text{CO}_3 \checkmark$ $n = Mm$ $m = nM = (0,0248)(286) = 7,093 \text{ g Na}_2\text{CO}_3 \checkmark \checkmark$ Marking guidelines: Calculate $n(\text{HCl})$ ✓ Use formula $C = n/V$ ✓ Use ratio, 1 : 2 ✓ Calculate $n \text{ Na}_2\text{CO}_3$ ✓ Calculate m of Na_2CO_3 ✓
--	---

- 3.2.6. Positive marking from question above
- % Na_2CO_3 in commercial washing soda = $\frac{\text{actual mass}}{\text{theoretical mass}} \times 100\% \checkmark$
- $$= \frac{7,092}{7,6} \times 100 \checkmark$$
- (3)



Question 4

4.1.

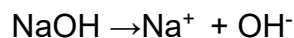
= 93,32 % ✓

If answer of 7,093 g is used then the answer is 93,33 %

4.2.

An acid is a proton donor. ✓✓

(2)



4.3.

0,75 mol.dm⁻³ (NaOH) gives 0,75 mol.dm⁻³ OH⁻ (Ratio 1:1) ✓

(1)

OPTION 1

$$\text{pOH} = -\log [\text{OH}^-]$$

$$\text{POH} = -\log[0,75] \checkmark$$

$$\text{POH} = 0,1249$$

$$\text{pH} + \text{POH} = 14$$

$$\text{pH} + 0,1249 = 14 \checkmark$$

$$\text{pH} = 13,88 \checkmark$$

OPTION 2

$$[\text{H}^+][\text{OH}^-] = 10^{-14}$$

$$[\text{H}^+][0,75] = 10^{-14} \checkmark$$

$$[\text{H}^+] = 1,3333 \times 10^{-14} \text{ mol.dm}^{-3}$$

$$\text{pH} = -\log [\text{OH}^-]$$

$$\text{pH} = -\log[1,3333 \times 10^{-14}] \checkmark$$

$$[\text{H}^+] = 13,88 \checkmark$$

N_{initial} (HCl)

$$c = \frac{n}{V} \checkmark$$

$$N_{\text{initial}} = cV$$

$$= (0,5)(0,075) \checkmark$$

$$= 0,0375 \text{ moles}$$

For the reaction between HCl (excess) and NaOH

N(NaOH) reacted n = cV

$$n = \underline{0,75 \times 0,022} \checkmark$$

$$n = 0,0165 \text{ moles}$$

$$n(\text{NaOH}) : n(\text{HCl}) = 1 : 1$$

$$n_{\text{excess}} (\text{HCl}) = 0,0165 \text{ moles (Ratio)} \checkmark$$

n_{reacted} (HCl) = with CaCO₃

$$n = \underline{0,0375 - 0,0165} \checkmark$$

$$n = 0,021 \text{ moles} \checkmark$$

use ratio:

$$n(\text{reacted})(\text{CaCO}_3) = 0,0105 \text{ mol} \checkmark$$

$$m = n \times M$$

$$m = (0,0105)(100) \checkmark$$

$$m = 1,05 \text{ g}$$

$$\% \text{ CaCO}_3 = \frac{1,05}{5} \times 100 \checkmark$$

$$= 21 \% \checkmark$$



Question 5

5.1.

5.1.1.

A substance that produces hydronium ion in solution. ✓✓

(2)

5.1.2.

An acid that donate 2one proton per molecule. ✓✓

(2)

- 5.1.3. Strong acid. ✓ It ionise completely in solution. ✓ (2)
- 5.1.4. a) $K_w = [H_3O^+][OH^-]$ ✓ (3)
 $1 \times 10^{-14} = [H_3O^+][1 \times 10^{-11}]$ ✓
 $[H_3O^+] = 0,001 \text{ mol.dm}^{-3}$ ✓
- b) $pH = -\log[H_3O^+]$ ✓ (3)
 $pH = -\log 0,001$ ✓
 $pH = 3$ ✓

- 5.2. 5.2.1. $CO_3^{2-} + H_2O \rightleftharpoons HCO_3^- + OH^-$ ✓✓bal. (3)
- 5.2.2. HCO_3^- ✓ (1)

Question 6

- 6.1. $pH = -\log[H_3O^+]$ ✓ (3)
 $2 = -\log[H_3O^+]$ ✓
 $[H_3O^+] = 10^{-2} \text{ mol.dm}^{-3}$ ✓
- 6.2. $n(HCl) = cV$ ✓ (7)
 $n = (0,03)(0,200) = 0,006 \text{ mol}$ ✓

HCl: NaOH 1:1 and pH is 2 $\therefore H_3O^+$ is excess
 $\therefore n H_3O^+ (\text{final solution}) = 0,01(0,150 + 0,200) = 0,01 \text{ mol}$ ✓
 $N(\text{reacted}) = 0,006 - 0,0035 = 0,0025 \text{ mol}$ ✓

NaOH: HCl 1:2 ✓
 $\therefore n(\text{initial NaOH}) = 0,0025 \text{ mol}$

$$c = \frac{n}{V} \quad c = \frac{0,0025}{0,150} \text{ ✓}$$

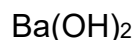
$$C = 0,0167 \text{ mol.dm}^{-3} \text{ ✓}$$

Question 7

- 7.1. HSO_4^- ✓✓ (2)
- 7.2.1. A substance that produces hydronium ions in solution. ✓✓ (2)
- 7.2.2. $pH = -\log[H_3O^+]$ ✓ (2)
 $pH = -\log(0,1)$ ✓
 $pH = 1$
- 7.3.3. NaOH $n = cV$ (7)
 $n = (0,1) \times (0,2)$ ✓
 $n = 0,02 \text{ mol}$



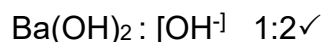
$$\text{in } 20\text{cm}^3 \dots = \frac{0,02 \text{ mol}}{250} \times 200\text{cm}^3 = 0,0016 \text{ mol} \checkmark$$



$$\text{Let } [\text{Ba(OH)}_2] = x$$

$$n = (x)(0,05)$$

$$n = 0,05x \text{ mol}$$



$$\therefore \text{in } 250\text{cm}^3 [\text{OH}^-] = 0,1x \text{ mol} / 250\text{cm}^3 \times 20\text{cm}^3 = 0,008x \text{ mol} \checkmark$$

$$\text{Total } n \text{ of } \text{OH}^- = 0,0016 + 0,008x \text{ mol} \checkmark$$

$$n \text{ H}_3\text{O}^+ \text{ from HCl} = (0,1)(30/1000) = 0,003 \text{ mol} \checkmark$$

at neutralisation moles of OH^- in 20cm^3 = moles of H_3O^+ from HCl

$$0,0016 + 0,008x = 0,003$$

$$x = 0,175 \text{ mol} \cdot \text{dm}^{-3} \checkmark$$

Question 8

8.1.1. A substance that can act as either acid or base. $\checkmark \checkmark$

(2)

8.1.2. $\text{HSO}_3^- \checkmark$

(1)

8.1.3. H_2SO_3 , $\text{HSO}_3^- \checkmark \checkmark$ and

(2)

H_2O , $\text{H}_3\text{O}^+ \checkmark \checkmark$

8.3. Bromothymol blue $\checkmark$

Is most suitable for a solution with a $\text{pH} = 7 \checkmark$

$$8.4.1. \quad n(\text{NaOH}) = cV$$

(2)

$$= (1,2)(0,2) \checkmark$$

$$= 0,24 \text{ mol} \checkmark$$

8.4.2. POSITIVE MARKING FROM QUESTION 8.4.1

(9)

$$\text{Therefore } (4 \times 0,040239 \text{ mol}) = 0,160956 \text{ mol in } 200 \text{ cm}^3 \checkmark \text{ (d)}$$

$$n_{\text{used}}(\text{HNO}_3) = n_{\text{initial}}(\text{HNO}_3) - n_{\text{excess}}(\text{HNO}_3)$$

$$n_{\text{used}}(\text{HNO}_3) = 0,24 - 0,160956 \checkmark \checkmark \text{ (e)}$$

$$n_{\text{used}}(\text{HNO}_3) = 0,079 \text{ mol}$$

$$m \quad n(\text{KOH}) = M$$

$$m \quad 0,079044 = 56 \checkmark \text{ (f)}$$

$$m = 4,426464 \text{ g}$$

$$\underline{4,426464}$$

$$\begin{aligned}\% \text{purity} &= 13 \times 100(\text{g}) \checkmark \\ &= 34,05\% \checkmark (\text{h})\end{aligned}$$

Question 9

9.1. Ionise incompletely in solution to form a low concentration of hydronium ions. $\checkmark$ (2)

9.2. $\text{H}_2\text{O} / \text{H}_3\text{O}^+$ and $\text{H}_2\text{C}_2\text{O}_4 / \text{HCO}_4^-$

9.3. Oxalic acid can donate two protons (H^+) during its ionisation in an aqueous solution/It ionises to form 2 protons. $\checkmark\checkmark$ (2)

9.4. A substance that can act as either an acid or a base. + Accept: a substance $\checkmark\checkmark$ (2)

9.5.1.

$c = \frac{m}{MV} \checkmark$ $= \underline{2,25}$ $90(0,25) \checkmark$ $C = 0,1 \text{ mol} \cdot \text{dm}^{-3} \checkmark$		
--	--	--

9.5.3. Phenolphthalein $\checkmark$ is a suitable indicator for the titration of oxalic acid and sodium hydroxide because the reaction involves a strong base (NaOH) and a weak acid ($\text{H}_2\text{C}_2\text{O}_4$). The endpoint of the titration occurs when the pH is greater than 7. $\checkmark$

OR

Because the salt of the titration will undergo hydrolysis and form a basic salt solution $\checkmark$

9.6.1. $c = \frac{m}{MV} \checkmark$
 $0,2 \checkmark = m / (58)(0,5) \checkmark$
 $m = 5,8 \text{ g} \checkmark$ (4)

9.6.2. $[\text{OH}^-] = 2(0,20) \checkmark$
 $[\text{OH}^-] = 0,4 \text{ mol} \cdot \text{dm}^{-3} \checkmark$ (2)

9.6.3. $[\text{H}_3\text{O}^+][\text{OH}^-] = 1 \times 10^{-14} \checkmark$
 $[\text{H}_3\text{O}^+](0,4) = 1 \times 10^{-14} \checkmark$
 $[\text{H}_3\text{O}^+] = 2,5 \times 10^{-14}$
 $\text{pH} = [\text{H}_3\text{O}^+] \checkmark$
 $\text{pH} = (2,5 \times 10^{-14}) \checkmark$
 $\text{pH} = 13,60 \checkmark$ NO, NOT SUITABLE for consumption (5)



MOMENTUM AND IMPULSE: SOLUTIONS

MULTIPLE CHOICE

- 1.1 D✓✓ (2)
- 1.2 B✓✓ (2)
- 1.3 A✓✓ (2)
- 1.4 D✓✓ (2)
- [8]

LONG QUESTIONS

QUESTION 2

- 2.1 In an isolated system the total (linear) momentum is conserved/remains constant✓✓ (2)

$$\sum p_i = \sum p_f \quad \checkmark$$

- 2.2 $m_A v_{iA} + m_B v_{iB} = m_A v_{fA} + m_B v_{fB}$
 $0 \checkmark = (3,2)(-0,4) + (2,6)v_f \checkmark$
 $\therefore v_f = 0,49 \text{ m} \cdot \text{s}^{-1}$

$$v = \frac{\Delta x}{\Delta t}$$

$$0,49 = \frac{\Delta x}{1,3} \checkmark = 0,64 \text{ m} \cdot \text{s}^{-1} \checkmark \quad (5)$$

- 2.3 $F_{\text{net}} \Delta t = \Delta p \checkmark$
 $F_{\text{net}} \Delta t = m(v_f - v_i)$
 $(4,2) \Delta t = 2,6(0,49 - 0) \checkmark$
 $\Delta t = 0,3 \text{ s} \checkmark$

- 2.4 LESS THAN ✓
 Final momentum/change in momentum/impulse remains constant. ✓
 If mass/inertia increases, velocity decreases/velocity inversely proportional to mass ✓ (3)

[13]

QUESTION 3

- 3.1 The total mechanical energy/sum of gravitational potential energy and kinetic energy, in an isolated system remains constant/is conserved. ✓✓ (2)

- 3.2 Total $E_{\text{mech}}(\text{top}) = \text{Total } E_{\text{mech}}(\text{bottom}) \checkmark$
 $(E_p + E_k)_{\text{top}} = (E_p + E_k)_{\text{bottom}}$
 $(mgh + \frac{1}{2}mv^2)_{\text{top}} = (mgh + \frac{1}{2}mv^2)_{\text{bottom}}$
 $(2)(9,8)(1,5) + 0 \checkmark = 0 + \frac{1}{2}(2)v^2 \checkmark$
 $v = 5,42 \text{ m} \cdot \text{s}^{-1} \checkmark$ (4)

3.3.1 $\Delta p = mv_f - mvi$ ✓

$F_{net}\Delta t = \Delta p$

$= 2(5,42 - 0)$ ✓

$= \underline{10,84 \text{ kg}\cdot\text{m}\cdot\text{s}^{-1} \text{ right}}$ ✓

(3)

3.3.2

$10,84 \text{ kg}\cdot\text{m}\cdot\text{s}^{-1}$ left /opposite direction ✓

(1)

3.4 $\Delta p_A = mv_f - mvi$

$\Sigma p_i = \Sigma p_f$

$10,84 = 1,5(v_f - 0)$ ✓

OR

$0 = 1,5v_f + (2)(5,42)$ ✓

$v_f = -7,23 \text{ m}\cdot\text{s}^{-1}$

$v_f = -7,23 \text{ m}\cdot\text{s}^{-1}$

$v = 7,23 \text{ m}\cdot\text{s}^{-1}$ ✓

$v = 7,23 \text{ m}\cdot\text{s}^{-1}$ ✓

(2)

[12]

QUESTION 4

4.1 In an isolated system the total (linear) momentum is conserved/remains constant. ✓✓ (accept closed system) (2)

4.2.1 $\Sigma p_i = \Sigma p_f$ ✓

$mAv_{Ai} + mBv_{Bi} = (mA + mB)v_f$

$(7,2)(0,4) + (0) = (7,2 + 5,3)v_f$ ✓

(3)

$v_f = 0,23 \text{ m}\cdot\text{s}^{-1}$ ✓

4.2.2 2 $F_{net}\Delta t = \Delta p$ ✓

Any one/

$F_{net}\Delta t = m(v_f - v_i)$ Enige een

$F_{net}(0,02) = 7,2(0,23 - 0,4)$ ✓

$F_{net} = -61,2$ ✓

$F_{net} = 61,2 \text{ N}$

(60,95 N to/tot 61,2 N)

(3)

[8]

QUESTION 5

5.1 The total linear momentum of an isolated system remains constant. (2)

5.2 **OPTION 1** $\Sigma p_i = \Sigma p_f$ ✓

$m_1v_{1i} + m_2v_{2i} = (m_1 + m_2)v_f$

$\{0,45(9) + 0,20(0)\} \checkmark = (0,45 + 0,20)v \checkmark$

$v = 6,23 \text{ m}\cdot\text{s}^{-1}$ ✓

OPTION 2

$\Delta p_{ball} = -\Delta p_{cont}$ ✓

$0,45(v - 9) \checkmark = -0,2(v - 0) \checkmark$

$v = 6,23 \text{ m}\cdot\text{s}^{-1}$ ✓

(4)

[11]

QUESTION 6

6.1 $mAv_{Ai} + mBv_{Bi} = (mA + mB)v_f$ ✓

$(87)v_{im} + 0 \checkmark = (87 + 22)(2,4)$ ✓

(4)

$$v_{im} = 3,01 \text{ m}\cdot\text{s}^{-1} \checkmark$$

6.2

Option 1

$$\begin{aligned} K(\text{before}) &= \frac{1}{2}mv^2 \checkmark \\ &= \frac{1}{2}(87)(3,01)^2 + 0 \checkmark \\ &= 394,11 \text{ J} \checkmark \\ &= (391,5 \text{ if } 3 \text{ m}\cdot\text{s}^{-1}) \end{aligned}$$

$$\begin{aligned} K(\text{after/na}) &= \frac{1}{2}mv^2 \\ &= \frac{1}{2}(109)(2,4)^2 \checkmark \\ &= 313,92 \text{ J} \checkmark \end{aligned}$$

Collision is inelastic / No $\checkmark$

Option 2

$$\begin{aligned} \Delta K &= K(\text{after}) - K(\text{before}) \\ &= \frac{1}{2}mv^2(\text{after}) - \frac{1}{2}mv^2(\text{before}) \checkmark \\ &= \frac{1}{2}(109)(2,4)^2 \checkmark - (\frac{1}{2}(87)(3,01)^2 \\ &\quad + 0) \checkmark \\ &= 313,92 - 394,11 \\ &= -80,19 \text{ J} \checkmark \end{aligned}$$

Collision is inelastic / No $\checkmark$

6.3

$$W_{\text{net}} = \Delta E_k \checkmark$$

$$\begin{aligned} F_{\text{net}} \Delta x \cos \theta \checkmark &= \frac{1}{2}m(v_f^2 - v_i^2) \\ F_{\text{net}}(2)(-1) \checkmark &= \frac{1}{2}(87+22)(0^2 - 2,4^2) \checkmark \\ F_{\text{net}} &= 156,96 \text{ N} \checkmark \end{aligned}$$

(6)

(5)

[15]

QUESTION 7

7.1

Isolated system is a system on which the resultant/net external force is zero. $\checkmark \checkmark$ (2)

7.2

$$\begin{aligned} p &= mv \checkmark \\ 24 &= m(480) \checkmark \\ m &= 0,05 \text{ kg} \checkmark \end{aligned} \quad (3)$$

7.3

$$\begin{aligned} F_{\text{net}} \Delta t &= \Delta p \checkmark \\ F_{\text{net}}(0,01) \checkmark &= (0,05)(80) - 24 \checkmark \\ F_{\text{net}} &= -2000 \text{ N} \\ F_{\text{net}} &= 2000 \text{ N} \checkmark \text{ west} \checkmark \end{aligned} \quad (5)$$

QUESTION 8

8.1

West $\checkmark$ (1)

8.2

(Newton's) Third Law (of Motion) $\checkmark$

When object A exerts a force on object B, object B exerts a force equal in magnitude on object A $\checkmark$, but opposite in direction. $\checkmark$ (3)

8.3

$$\begin{aligned} \Sigma p_i &= \Sigma p_f \checkmark \\ 0 \checkmark &= (60)v_f + (5)(4) \checkmark \\ \therefore v_f &= -0,33 \checkmark \\ \therefore v_f &= 0,33 \text{ m}\cdot\text{s}^{-1} \checkmark \end{aligned} \quad (5)$$

8.4.1 Increases ✓ (1)

8.4.2 Increases ✓, Δp package increases, thus Δp boy increases ✓.
• For the same mass of the, v will be greater. ✓ (3)

[13]

QUESTION 9

9.1 Momentum is the product of the mass and velocity of an object. ✓✓ (2)

$$\Delta p = 0 \quad \checkmark$$

9.2 $F_{\text{net}} = \frac{\Delta p}{\Delta t} = 0 \quad \checkmark$

OR $\Delta p = 0 \quad \checkmark \quad \Delta v = 0$

$\therefore a = 0 \therefore F_{\text{net}} = ma \quad \checkmark$ (2)

9.3

OPTION 1

$$F_{\text{net}} \Delta t = \Delta p \quad \checkmark$$

$$= -120 - 50 \quad \checkmark$$

$$= -170$$

$$\therefore F_{\text{net}} \Delta t = 170 \text{ N} \cdot \text{s} / \text{kg} \cdot \text{m} \cdot \text{s}^{-1} \quad \checkmark$$



OPTION 2

$$F_{\text{net}} = \frac{\Delta p}{\Delta t} \quad \checkmark$$

$$= \frac{-120 - 50}{50 - 20}$$

$$\therefore F_{\text{net}} = -5,67$$

$$F_{\text{net}} \Delta t = (-5,67)(30) \quad \checkmark$$

$$= -170$$

$$\therefore F_{\text{net}} \Delta t = 170 \text{ N} \cdot \text{s} / \text{kg} \cdot \text{m} \cdot \text{s}^{-1} \quad \checkmark$$

(3)

9.4

OPTION 1

$$1 \quad \Sigma p_i = \Sigma p_f \quad \checkmark$$

$$-120 + 70 \quad \checkmark = 50 + p_{Bf} \quad \checkmark$$

$$\therefore p_{Bf} = -100$$

$$\therefore p_{Bf} = 100 \text{ kg} \cdot \text{m} \cdot \text{s}^{-1} \quad \checkmark \text{ west} \quad \checkmark$$

OPTION 2

$$\Delta p_A = -\Delta p_B \quad \checkmark$$

$$50 - (-120) \quad \checkmark = -(p_{Bf} - 70) \quad \checkmark$$

$$\therefore p_{Bf} = -100$$

$$\therefore p_{Bf} = 100 \text{ kg} \cdot \text{m} \cdot \text{s}^{-1} \text{ west} \quad \checkmark$$

(5)

[12]

QUESTION 10

10.1 Impulse is the product of the (net/average) force and the time during which the force acts. ✓✓ (2)

10.2 $F_{\text{net}} \Delta t = \Delta p \quad \checkmark$
 $= m(v_f - v_i)$
 $= 0,15(3,62 - (-6,2)) \quad \checkmark$
 $= 1,473 \text{ N} \cdot \text{s} / \text{kg} \cdot \text{m} \cdot \text{s}^{-1} \quad \checkmark \text{ upward}$ (3)

10.3 $(U + K)_{\text{top}} = (U + K)_{\text{bottom}}$ ✓ ✓

$$mgh_f + \frac{1}{2} m v_f^2 = mgh_i + \frac{1}{2} m v_i^2 \quad (0,15)(9,8)h + 0 \quad \checkmark$$

$$= 0 + \frac{1}{2}(0,15)(6,2)^2 \quad \checkmark$$

$$\therefore h = 1,96 \text{ m} \quad \checkmark$$

$$\frac{1,96}{3} = 0,65 \text{ m Yes/Meets requirements} \quad \checkmark$$

(5)
[10]

ELECTRIC CIRCUITS: SOLUTIONS

MULTIPLE CHOICE QUESTIONS

1.1 A ✓ ✓ (2)

1.1 C ✓ ✓ (2)

1.1 D ✓ ✓ (2)

1.2 C ✓ ✓ (2)

LONG QUESTIONS

QUESTION 2

2.1.1 The potential difference across a conductor is directly proportional to the current in the conductor at constant temperature. ✓ ✓ (2)

2.1.2 Graph X, ✓
Graph X is a straight line, therefore potential difference is directly proportional to current. ✓ (2)

2.2.1
$$\frac{1}{R_p} = \frac{1}{R_{10}} + \frac{1}{R_{15}}$$

$$= \frac{1}{10} + \frac{1}{15} \quad \checkmark$$

$$= 6 \, \Omega$$

$$\therefore R = (10 + 6 + 2) \quad \checkmark$$

$$= 18 \, \Omega$$

$$R = \frac{V}{I} \quad \checkmark$$

$$18 = \frac{6}{I} \quad \checkmark$$

$$I = 0,33 \text{ A} \quad \checkmark$$

2.2.2 Decrease ✓
The total resistance of the circuit increases. ✓ (2)

2.2.3 Increase ✓ (1)

2.2.4 The total resistance in the external circuit increases ✓
Current decreases ✓
"Lost" volts decreases ✓ (3)

[15]

QUESTION 3

3.1.1 The potential difference across a conductor is directly proportional to the current in the conductor at constant temperature. ✓✓ (2)

3.1.2 **Diagram 1:**

$$R_Y = \frac{V}{I} \checkmark$$

$$= \frac{6}{2} \checkmark$$

$$= 3 \, \Omega \checkmark$$

Diagram 2:

$$V_Y = \varepsilon - V_X$$

$$= 6 - 4$$

$$= 2 \, \text{V}$$

$$R_Y = \frac{V}{I}$$

$$3 = \frac{2}{I} \checkmark$$

$$I_Y = 0,67 \, \text{A}$$

$$R_X = \frac{V}{I}$$

$$= \frac{4}{0,67} \checkmark$$

$$= 5,97 \, \Omega \checkmark$$

3.2.1 12,6 V ✓

3.2.2 $\varepsilon = I(R+r)$ ✓

$$12,6 \checkmark = I(5+0,08) \checkmark$$

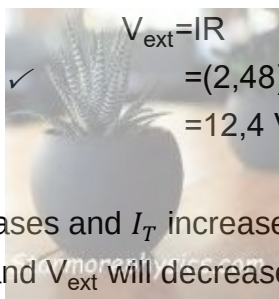
$$I = 2,48 \, \text{A}$$

3.2.3 Decrease ✓

Resistance decreases and I_T increases ✓

V_{int} will increase and V_{ext} will decrease (with emf constant) ✓

(According to $P = \frac{V^2}{R}$), power will decrease ✓



(5)

(4)

[18]

QUESTION 4

4.1 3,11 J of energy is transferred per one coulomb of charge ✓✓ (2)

4.2.1 **OPTION 1**

$$V = IR_2 \checkmark$$

$$1,6 = 0,2R_2 \checkmark$$

$$R_2 = 8 \, \Omega$$

$$V = IR$$

$$= 0,2(4+8) \checkmark$$

$$= 2,4 \, \text{V} \checkmark$$

4.2.2 **OPTION 1**

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$= \frac{1}{2} + \frac{1}{(4+8)} \checkmark$$

$$R_p = 1,71 \, \Omega$$

$$V_p = IR$$

$$2,4 = I(1,71) \checkmark$$

OPTION 2

$$V_{\text{ext}} = V_{4\Omega} + V_{R_2} \checkmark$$

$$= IR_1 + V_2$$

$$= 0,2(4) \checkmark + 1,6 \checkmark$$

$$= 2,4 \, \text{V} \checkmark$$

OPTION 2

$$V = IR$$

$$2,4 = I(2) \checkmark$$

$$I = 1,2 \, \text{A}$$

$$I_{\text{Tot}} = 1,2 + 2 \checkmark$$

$$= 1,4 \, \text{A} \checkmark$$

(4)

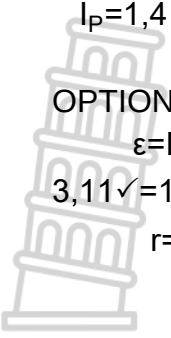
(3)



4.2.3 **OPTION 1**

$$\epsilon = I(R+r)$$

$$3,11\checkmark = 1,4(1,71+r)\checkmark$$

$$r = 0,51\ \Omega\checkmark$$


OPTION 2

$$V_{\text{lost}} = \epsilon - V_{\text{ext}}$$

$$= 3,11 - 2,4\checkmark$$

$$= 0,71\text{ V}$$

$$V_{\text{lost}} = IR$$

$$0,71 = 1,4r\checkmark$$

$$r = 0,51\ \Omega\checkmark$$

(3)

4.2.4 **OPTION 1**

$$P = VI\checkmark$$

$$= 0,714(1,4)\checkmark$$

$$= 0,9996\text{ W}\checkmark$$

OPTION 2

$$P = I^2 R\checkmark$$

$$= (1,4)^2(0,51)\checkmark$$

$$= 0,9996\text{ W}\checkmark$$

OPTION 3

$$P = \frac{V^2}{R}\checkmark$$

$$= \frac{(0,714)^2}{(0,51)}\checkmark$$

$$= 0,9996\text{ W}\checkmark$$

(3)

[15]

QUESTION 5

5.1 The maximum energy provided by a battery per unit charge passing through it✓✓ (2)

5.2

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\checkmark$$

$$= \frac{1}{5} + \frac{1}{10} + \frac{1}{20}\checkmark$$

$$\therefore R = 2,86\ \Omega\checkmark$$

(3)

5.3 **OPTION 1**
Diagram B

- The total resistance of the circuit increase✓
- Total current decrease✓
- The V_{internal} decreases✓
- Therefore V_{ext} increases

OPTION 2
Diagram A

- The total resistance of the circuit decreases✓
- Total current increases✓
- The V_{internal} increases
- Therefore V_{ext} decreases

(3)

5.4.1

$$R = \frac{V}{I}\checkmark$$

$$2,86 = \frac{10}{I}\checkmark$$

$$\therefore I = 3,50\text{ A}\checkmark$$

5.4.2 **Diagram A**

$$\epsilon = I(R+r)\checkmark$$

$$= 3,5(2,86+r)\checkmark \text{ ----- (1)}$$

Diagram B

$$V = IR$$

$$12 = \frac{I}{5,5}$$

$$I = 2,18\text{ A}$$

$$\epsilon = I(R+r)$$

$$= 2,18(5,5+r)\checkmark \text{ ----- (2)}$$

Equation 1 = Equation 2

$$3,5(2,86+r) = 2,18(5,5+r)\checkmark$$

$$r = 1,5\ \Omega\checkmark$$

(5)

5.4.3 $\epsilon = I(R+r)$
 $= 3,5(2,86+1,5) \checkmark$
 $= 15,26 \text{ V} \checkmark$ (2)

5.4.4 **OPTION 1** **OPTION 2** **OPTION 3**

$P = I^2 R \checkmark$ $P = \frac{V^2}{R} \checkmark$ $P = VI \checkmark$

$= (2,18)^2 (5,5) \checkmark$ $= \frac{(12)^2}{5,5} \checkmark$ $= (12)(2,18) \checkmark$

$= 26,14 \text{ W} \checkmark$ $= 26,18 \text{ W} \checkmark$ $= 26,16 \text{ W} \checkmark$ (3)

- 5.5
- The voltmeter reading INCREASES $\checkmark$
 - Total resistance increases and total current decreases $\checkmark$
 - V_{int} decreases $\checkmark$
- (3)

[24]

QUESTION 6

6.1.1 To change/vary the external resistance in the circuit in order to change/vary the (total) current through the battery. $\checkmark \checkmark$ (2)

6.1.2 Current $\checkmark$ (1)

6.1.3 Internal resistance $\checkmark$ (1)

6.1.4 6 V $\checkmark$ (1)

6.1.5 $V_{\text{int}} = 6 - 2 \checkmark = 4 \text{ V} \checkmark$ (2)

6.2.1 The maximum energy provided by a battery per unit charge passing through it $\checkmark \checkmark$ (2)

6.2.2 $P = VI \checkmark$ $R_{6\Omega} = \frac{V}{I}$

$12 = V(2) \checkmark$ $6 = \frac{18}{I} \checkmark$

$V_{12W} = 6 \text{ V}$ $I_{6\Omega} = 3 \text{ A}$

$V_{6\Omega} = IR$
 $= (2)(6) \checkmark$
 $= 12 \text{ V}$

$I_{\text{Tot}} = 3 + 2 \checkmark = 5 \text{ A}$

$V_P = 12 + 6 = 18 \text{ V}$

$V_S = IR$
 $= (5)(2) \checkmark$
 $= 10 \text{ V}$

$P = \frac{V^2}{R}$
 $12 = \frac{6^2}{R} \checkmark$
 $R_{12W} = 3 \Omega$

$V_{\text{ext}} = V_P + V_S$
 $= 18 + 10$
 $= 28 \text{ V} \checkmark$

6.2.3 **OPTION 1**

$r = \frac{V_{\text{int}}}{I} \checkmark$
 $= \frac{30 - 28}{5} \checkmark$
 $= 0,4 \Omega \checkmark$

OPTION 2

$\epsilon = I(R+r) \checkmark$
 $30 = 5(5,6+r) \checkmark$
 $r = 0,4 \Omega \checkmark$

(8)

(3)

6.2.4 Increase $\checkmark$

Total resistance in circuit increase and the total current decrease ✓

V_{internal} will decrease. ✓

Therefore: V_{external} will increase because emf stays constant ✓

(4)

[24]

QUESTION 7

7.1.1 The potential difference across a conductor is directly proportional to the current in the conductor at constant temperature. ✓✓

(2)

7.1.2 $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$ ✓

$$\frac{1}{R_p} = \frac{1}{(7+6)} + \frac{1}{(4+6)} \checkmark$$

$$R_p = 5,65 \, \Omega \checkmark$$

(4)

7.1.3 **OPTION 1**

$$\varepsilon = I(R+r) \checkmark$$

$$15 = I(5,65 + 0,45) \checkmark$$

$$I = 2,46 \, \text{A} \checkmark$$

OPTION 2

$$R_T = \frac{V_T}{I} \checkmark$$

$$(5,65 + 0,45) = \frac{15}{I} \checkmark$$

$$I = 2,46 \, \text{A} \checkmark$$

(3)

7.1.4

OPTION 1		OPTION 2	
$r = \frac{V}{I}$ $0,45 = \frac{V}{2,46} \checkmark$ $V_{\text{int}} = 1,11 \, \text{V}$ $V_T = V_{\text{ext}} + V_{\text{int}}$ $15 = V_{\text{ext}} + 1,11$ $V_{\text{ext}} = 13,89 \, \text{V}$	$R = \frac{V}{I}$ $5,56 = \frac{V}{2,46} \checkmark$ $V_{\text{ext}} = 13,89 \, \text{V}$	$r = \frac{V}{I}$ $0,45 = \frac{V}{2,46} \checkmark$ $V_{\text{int}} = 1,11 \, \text{V}$	$R = \frac{V}{I}$ $5,56 = \frac{V}{2,46} \checkmark$ $V_{\text{ext}} = 13,89 \, \text{V}$
Current through 7 Ω and 6 Ω $R = \frac{V}{I}$ $13 = \frac{13,89}{I} \checkmark$ $I = 1,07 \, \text{A}$		Current through 7 Ω and 6 Ω $R = \frac{V}{I}$ $13 = \frac{13,89}{I} \checkmark$ $I = 1,07 \, \text{A}$	
Potential difference across 7 Ω $R_{7\Omega} = \frac{V}{I}$ $7 = \frac{V}{1,07} \checkmark$ $V = 7,49 \, \text{V}$		Potential difference across 6 Ω $R_{6\Omega} = \frac{V(B)}{I}$ $R_{6\Omega} = \frac{V}{1,39} \checkmark$ $V = 8,34 \, \text{V}$	
Potential difference across 4 Ω $R_{4\Omega} = \frac{V}{I}$ $4 = \frac{V}{1,39} \checkmark$ $V = 5,56 \, \text{V}$		Potential difference across 6 Ω $R_{7\Omega} = \frac{V(A)}{I}$ $6 = \frac{V}{1,07} \checkmark$ $V = 6,42 \, \text{V}$	

$V_A = 13,89 - 7,49$ $= 6,40 \text{ V}$	$V_B = 13,89 - 5,56$ $= 8,33 \text{ V}$		
			
$V_2 = V_B - V_A$ $V_2 = 8,33 - 6,40$ $V_2 = 1,93 \text{ V} \checkmark$		$V_2 = V_B - V_A$ $V_2 = 8,34 - 6,42 \text{ V}$ $V_2 = 1,92 \text{ V} \checkmark$	

7.2 Increases $\checkmark$

(1)

7.3 Total resistance increases and total current decreases. $\checkmark$

V lost decreases $\checkmark$

7.4 Cost = energy $\times$ tariff

$$300 \checkmark = (P \times 8 \times 30) \times 2,59 \checkmark$$

$$P = 482,625 \text{ W} \checkmark$$

$$\begin{aligned} \text{No. of bulbs} &= \frac{482,625}{80} \checkmark \\ &= 6 \checkmark \end{aligned}$$



(5)

[24]