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QUESTION 1

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

(10 x 2) [20]

QUESTION 2

- 2.1 A force of attraction ✓ between molecules, ions or atoms of noble gases ✓ (2)

2.2

	Description	Answer	
2.2.1	is a polar molecule which has polar covalent bonding	HF ✓	(1)
2.2.2	is a compound which has pure covalent bonding	PH ₃ ✓	(1)
2.2.3	has hydrogen bonding	HF ✓	(1)
2.2.4	shows bonding between a positive kernel and a sea of delocalised electrons	Fe ✓	(1)
2.2.5	forms a giant covalent network structure	Graphite ✓	(1)
2.2.6	is formed through the transfer of electrons and subsequent electrostatic attraction	NaF ✓	(1)
2.2.7	experiences only van der Waals forces between its atoms	He ✓	(1)
2.2.8	has polar intramolecular bonds and experiences only induced dipole or dispersion forces between its molecules	CO ₂ ✓	(1)

[10]

QUESTION 3

- 3.1 3 minutes ✓ (1)

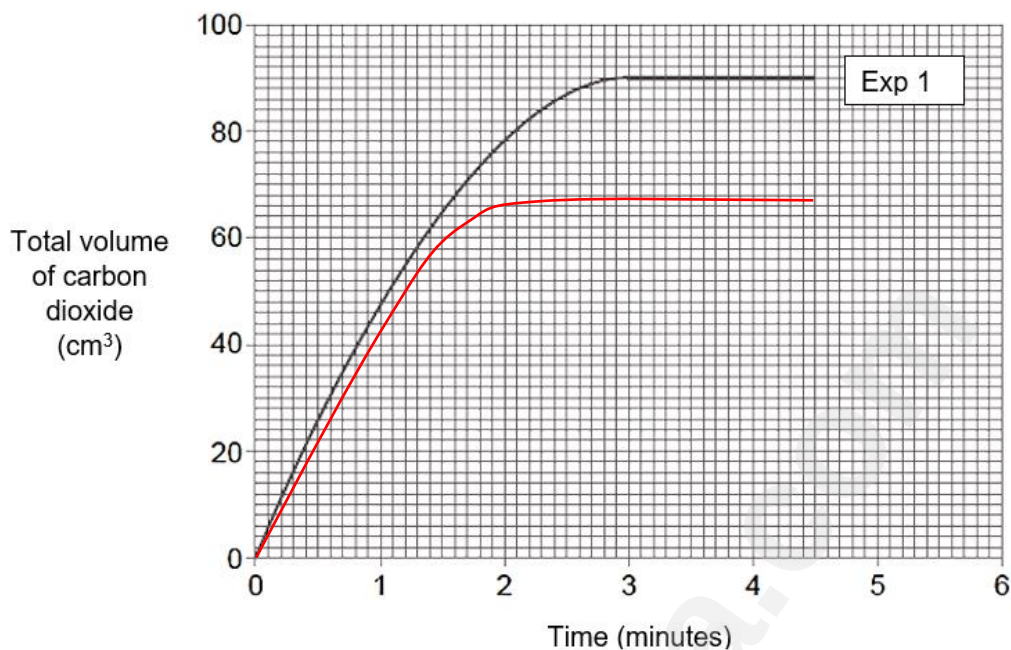
- 3.2 90 cm³ ✓ (1)

- 3.3 $\overline{rate} = \frac{V_{CO_2}}{\Delta t} = \frac{90}{3(60)} \text{ ✓subs✓conv} = 0,5 \text{ cm}^3 \cdot \text{s}^{-1} \text{ ✓}$ (3)

- 3.4 $n_{HCl} = \frac{V}{V_M} \text{ ✓} = \frac{90 \times 10^{-3}}{24} \text{ ✓} = 0,00375 \text{ mol ✓}$
- $n_{CO_2} : n_{HCl} \text{ is } 1:2 \text{ ✓} ; 0,0075 \text{ mol HCl ✓}$ (5)

- 3.5 ✓ very similar gradient to Exp 1 (or a little bit lower),
 ✓ end volume is $\frac{1}{4}$ lower (to within 1 block either way.) V should be 67,5 $\approx$ 68

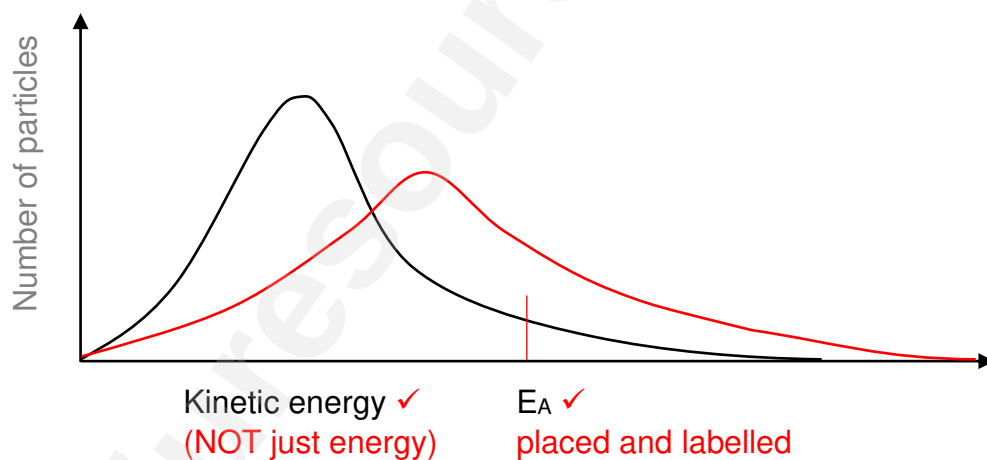
(2)



- 3.6.1 *Activation energy*: the minimum energy required to start a chemical reaction OR the energy required to form the activated complex ✓ ✓

(2)

3.6.2



(2)

- 3.6.3 ✓ curve peak further to right of Exp 1
 ✓ peak is lower than Exp 1 line

(2)

3.7

- Experiment 3 – higher temperature
- $\therefore$ particles have greater velocity ✓ (move faster) $\therefore$ more collisions per unit time ✓.
- ALSO, particles have greater kinetic energy and thus more particles have $E_k \geq E_A$ ✓
 $\therefore$ more effective collisions per unit time ✓ (penalise once for per unit time)
- $\therefore$ reaction 3 has a greater rate ✓.

(5)

- 3.8 rate $\propto [\text{HCl}]^2$ ✓ (all right or zero marks, inclusion of CaCO_3 (s) not possible as solids have no concentration effect)

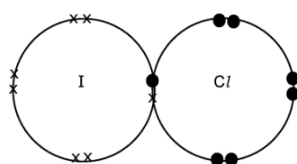
(1)

- Apply: rate $\propto [\text{HCl}]^2$ $\therefore$ new rate (due to $\Delta[\]$) $\propto [\text{HCl}/2]^2$
 $\therefore$ new rate (due to $\Delta[\]$) $\propto 1/4$ original rate
OR conc effect is halved and squared ✓ (effect of $\Delta[\]$ quantified)
- BUT, the increase in temperature roughly doubles the rate ✓ (compare to Temp – no coe)
- $\therefore$ concentration effect is more significant than temperature effect OR overall the effect is to halve the rate ✓ (state which effect has more impact – coe)
- $\therefore$ Rate of reaction 4 will be less than rate of reaction 1 ✓ (4)

[28]

QUESTION 4

4.1.1



(without the circles)

- ✓ correct valence electrons on both and
- ✓ 1 covalent shared pair

(2)

4.1.2 Forward rate > reverse rate ✓

(1)

4.1.3 The concentrations ✓ (or amounts) of all substances remain constant ✓ (horizontal lines) (2)

4.1.4 $K_c = \frac{[\text{ICl}_3]}{[\text{ICl}][\text{Cl}_2]}$ ✓

$K_c = \frac{(0,4)}{(0,2)(0,1)}$ ✓ ✓ subs $(-1[\]) = 20$ ✓ (4)

4.1.5 *Le Châtelier's principle*: When an external stress (change in pressure, temperature or concentration) is applied to a system in dynamic chemical equilibrium, the equilibrium point will change in such a way as to counteract the stress (all 4 parts for 2 marks) (2)

4.1.6 forward ✓ (1)

4.1.7 more yellow or less brown ✓ (1)

4.1.8 increase ✓ in pressure ✓ (2)

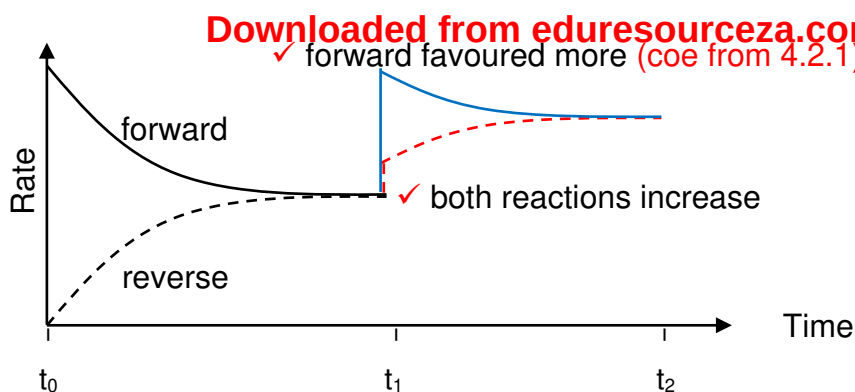
4.1.9

- An increase in temperature always favours the endothermic reaction ✓
- A decreased K_c shows that the reverse reaction was favoured ✓
- Thus the reverse is endothermic and forward is exothermic ✓ application of prev 2 points
- Therefore sign for ΔH is negative ✓ (4)

4.2.1

- The pressure of the system was increased ✓
- (both forward and reverse reactions increased their rates, but) **not for marks here**
- According to LCP, the reaction that produces fewer moles is favoured ✓ more
- Thus the forward reaction is favoured ✓
- thus more product is made and yield is increased ✓ (4)

4.2.2



4.2.3 Rate of product production increases ✓ because the graph shows that at the new equilibrium from t_2 onwards, the rate of the forward reaction is higher than at the first equilibrium (before t_1) ✓.

(2)

4.2.4 Any disturbance to shift equilibrium to the right and favour forward reaction such as remove product continuously / add reactant continuously / lower temperature. ✓

(1)

4.2.5 Use a catalyst / increase temperature ✓

(1)

[29]

QUESTION 5

5.1.1 HA^- ✓

(1)

5.1.2 For NaOH:

$$n_{\text{NaOH}} = cV \text{ ✓ formula}$$

$$= 0,112 \times 0,025 \text{ (✓ both subs ✓ conv.)} = 0,0028 \text{ mol}$$

$$n_{\text{NaOH}} : n_{\text{H}_2\text{A}} \text{ is } 2:1 \therefore 0,0014 \text{ mol H}_2\text{A} \text{ (ratio applied – mark below in subs)}$$

$$\text{Average volume in titration} = 26,55 \text{ cm}^3$$

$$c_{\text{H}_2\text{A}} \text{ in titration} = \frac{n}{V} = \frac{0,0014 \text{ ✓}}{0,02655 \text{ ✓}} \text{ subs – must be as V and penalise for conv. error only once}$$

$$= 0,053 \text{ mol. dm}^{-3} \text{ ✓ no coe if conv. error}$$

(6)

$$5.1.3 \quad n_{\text{H}_2\text{A}} \text{ original solution} = cV_{\text{original}}$$

$$= (0,053 \text{ ✓ coe})(0,25 \text{ ✓ coe conv. error from 5.1.2 all the way to ans})$$

$$= 0,013 \text{ mol}$$

$$n_{\text{H}_2\text{A}} = \frac{m}{M_r} \text{ ✓ formula}$$

$$0,013 = \frac{1,3}{M_r} \text{ ✓ subs} = 98,1 \text{ ✓ (g. mol}^{-1} \text{ unit not required)}$$

(5)

5.1.4 accuracy ✓

(1)

5.1.5 The final burette reading will be greater than ✓ expected

(1)

5.1.6 The water does not react with the alkali OR it does not change the number of moles of alkali OR water is a product of neutralisation, not a reactant

(1)

5.2.1 strong ✓

(1)

5.2.2 24 cm^3 ✓ no unit no mark

(1)

5.2.3 the acid has the greater concentration ✓ (reason - n:n is 1:1 but V_{acid} is less)

(1)

5.2.4 Cresolphthalein ✓

(1)

5.2.5

- As OH^- ions are added to the flask they react with H_3O^+ ions, thus lowering the $[\text{H}_3\text{O}^+]$ in the indicator equilibrium ✓ (concept of reaction to cause decreased $[\text{H}_3\text{O}^+]$)
- $\therefore$ forward reaction of the indicator equilibrium is favoured ✓
- $\therefore$ increase in $[\text{In}^-]$ ✓
- $\therefore$ solution becomes more/deeper/darker purple ✓ (not just purple) – coe for chosen indicator (4)

5.2.6 hydrolysis of a salt: a reaction of an ion (from a salt) ✓ with water ✓ (2)

5.2.7

- In its reaction with water, the ethanoate ion causes hydrolysis because it forms a weak acid which does not (re-)ionise completely. ✓
- $\text{CH}_3\text{COO}^- + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{COOH} + \text{OH}^-$ ✓ correct reaction with double arrow & linked reasoning
- This causes an increase in the $[\text{OH}^-]$ so that it is in excess in the solution ✓
- Resulting in the solution being alkaline ✓ (4)

OR

- In its reaction with water, the ethanoate ion causes hydrolysis because it forms a weak acid which does not ionise completely. ✓

- The formation of the weak acid removes hydrogen ions from the solution thus decreasing $[\text{H}_3\text{O}^+]$
- $\therefore$ water decomposes and the forward reaction of the auto-ionisation of water is favoured to replace H_3O^+ ions ✓ main concept using Kw; can also give the equations below but they are not sufficient alone to explain the increase in $[\text{OH}^-]$
- $$\begin{array}{ccccccc} \text{CH}_3\text{COOB} & \rightarrow & \text{B}^+ & + & \text{CH}_3\text{COO}^- & & \\ & & & & + & & \\ \text{H}_2\text{O} & \rightleftharpoons & \text{OH}^- & + & \text{H}^+ & \text{(carried by a water molecule as } \text{H}_3\text{O}^+) & \\ & & & & \downarrow & & \\ & & & & \text{CH}_3\text{COOH} & & \end{array}$$

- This causes an increase in the $[\text{OH}^-]$ so that it is in excess in the solution ✓
- Resulting in the solution being alkaline ✓ (4)

OR

- CH_3COO^- is the weak conjugate base of the weak acid, CH_3COOH
- CH_3COO^- ion (in a salt) causes hydrolysis because it would form a weak conjugate acid in its reaction with water. This weak acid would not ionise completely ✓ as per equation below:
 $\text{CH}_3\text{COO}^- + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{COOH} + \text{OH}^-$ ✓ correct reaction with double arrow & linked reasoning
- $\therefore$ resulting in an excess of OH^- ions ✓
- and an alkaline salt solution. ✓ (4)

[29]

QUESTION 6

6.1 Oxidation is the loss of electrons ✓✓ (1)

6.2 Anode ✓ as oxidation occurs at the anode ✓ and oxidation causes the conversion of a metal to its ion which looks like corrosion and reduces mass of solid electrode ✓ shows link between oxidation and the observation. (3)

6.3 Aqueous solutions of ions: $1 \text{ mol} \cdot \text{dm}^{-3}$ ✓
Temperature: 25°C ✓ (2)

6.4 $E^{\theta}_{\text{cell}} = E^{\theta}_{\text{cat}} - E^{\theta}_{\text{an}}$ **Downloaded from eduresourceza.com**
 $+2 = E^{\theta}_{\text{X}} - (-1,66)$ ✓✓subs
 $= +0,34 \text{ V}$ ✓ (4)



Negative marking for each type of error:

- ID of **X** based on 6.4
- order of anode and cathode swapped (unless based on coe error from 6.4)
- elements not on outside with ions on inside
- phases
- use of structures ($\mid$ and $\parallel$)

6.6.1 KCl/KNO_3 ✓✓ any soluble salt that doesn't form precipitates with Al or Cu and is not a stronger oxidising agent than Al^{3+} ; with correct formula (2)

6.6.2 Completes the circuit ✓ maintains the electrical neutrality of the half-cells ✓ (2)

6.7 DECREASE ✓ (1)

6.8.1 DECREASE ✓ (1)

6.8.2 X^{2+} or Cu^{2+} ions are removed through precipitation thus decreasing the $[\text{Cu}^{2+}]$ (a reactant) ✓ which favours the reverse reaction ✓ (and decreases the emf). (2)

6.9.1 CURRENT ALONE ✓ (1)

6.9.2 Increased surface area of a solid increases only the rate of the reaction ✓ (hence I) (1)

[24]

QUESTION 7

7.1.1 Electrical energy $\rightarrow$ chemical energy (2)

7.1.2

- A high concentration of copper chloride solution or high concentration of chloride ions ✓
- The strength of chloride ions and water as reducing agents are similar ✓ (Their electrode potentials are very similar: 1,23 V and 1,36 V respectively),
- if the concentration of chloride ions is sufficiently high, they will be oxidized in preference to water ✓ OR increased concentration of the chloride ions allows the formation of chlorine gas to happen at a greater rate (3)

7.1.3 (a) $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$ ✓ and arrow single ✓ (2)

(b) $n_{\text{Cu}} : n_{\text{e}^-}$ is 1 : 2 therefore 0,005 : 0,01 mol of e^- ✓use of ratio applied to n

$$Q = nF = (0,01)(96500) \text{ ✓use of correct constant with n (marked above) } = 965 \text{ C}$$

$$Q = It \text{ ✓ formula mark for both equations OR for } It = nF$$

$$965 = I(5 \times 60) \text{ ✓}$$

$$I = 3,22 \text{ A} \text{ ✓} \quad (5)$$

- 7.2.1 Negative ✓ Downloaded from eduresourceza.com (1)
- 7.2.2 O₂ or oxygen (gas) ✓ (1)
- 7.2.3
- The gas forms when the anodes of the cell have reacted with oxygen produced in the cell ✓
 - Thus the anodes are consumed/used up/get smaller and need to be replaced ✓ regularly. (2)
- 7.2.4
- Cryolite reduces the melting point of Alumina ✓
 - thus requiring less energy/electricity ✓ (and less cost) to run. (2)

[18]

QUESTION 8

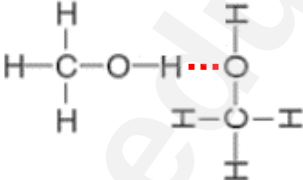
- 8.1.1 alcohols ✓ (1)
- 8.1.2 hydroxyl ✓ group (1)
- 8.1.3 Structural isomers are *compounds having the same molecular formula ✓ but different structural formulae ✓* (2)

8.1.4

	EITHER	OR	
Type of isomerism	Positional isomers	Chain isomers	✓
IUPAC name of isomer	heptan-2-ol heptan-3-ol heptan-4-ol	All names must remain an-1-ol 2-methylhexan-1-ol 3-methylhexan-1-ol 2,2-dimethylpentan-1-ol 2,3-dimethylpentan-1-ol 3,3-dimethylpentan-1-ol 2,2,3-trimethylbutan-1-ol ethylpentan-1-ol	✓

(2)

- 8.1.5 Heptan-1-ol: London forces ✓
Methanol: Hydrogen bonds ✓ (2)

- 8.1.6
- 
- ✓ correctly drawn methane molecule
- ✓ hydrogen bond between H of one molecule and O of another (2)

- 8.1.7 heptan-1-ol has:
- a longer carbon chain ✓ than methanol
 - ∴ more points of contact for more temporary dipoles to form ✓ (more points of contact alone is insufficient)
 - ∴ more (London) forces form between molecules ✓
 - ∴ more energy is required to overcome/break the forces of attraction ✓ (4)

8.1.8 heptan-1-ol is less soluble than methanol because.

- Polarity of organic molecule: ✓
 - heptan-1-ol is less polar or
 - heptan-1-ol has a longer non-polar chain or
 - heptan-1-ol is only weakly or slightly polar
- Comparison to water: ✓
 - water is highly polar
- Link: ✓
 - the IMF are not of the same nature or magnitude ($\therefore$ not soluble) or
 - the two substances are not alike and only like dissolves like or
 - the heptan-1-ol molecules don't attract the water ($\therefore$ not soluble)

8.2.1 methyl propanoate ✓ ester format with m and p swapped, ✓✓ fully correct (2)

8.2.2

Bonds broken:	Propanoic acid: C–OH	Methanol: O–H
Bonds made:	Ester: C–O–C	Water: H–OH

8.2.3

$$\begin{array}{ccccccc}
 & & \text{O} & \text{H} & \text{H} & \text{H} & \\
 & & || & | & | & | & \\
 \text{H} & - & \text{O} & - & \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - & \text{H} \\
 & & & & | & | & | & \\
 & & & & \text{H} & \text{H} & \text{H} &
 \end{array}$$

✓ carboxylic acid functional group correct

✓ 4 C

-1 per additional error such as extra/missing H atoms (2)

[24]

QUESTION 9

- 9.1.1 A saturated compound is a compound in which all of the bonds between carbon atoms are single bonds ✓ (2)
- 9.1.2 Addition ✓ (1)
- 9.1.3 There are double bonds present OR it is an unsaturated compound ✓ (1)
- 9.2.1 Hydration ✓ (1)
- 9.2.2 Water as steam ✓ (insufficient to say heat or high temp – must be water in gaseous phase) (1)
- 9.2.3 hex-1-ene OR hex-2-ene ✓ hex and ene ✓ number correct with dashes (2)
- 9.3.1 Substitution ✓ (1)
- 9.3.2 Heat ✓ $\frac{1}{2}$ under reflux ✓ $\frac{1}{2}$ in a dilute ✓ $\frac{1}{2}$ alkali (base) solution. ✓ $\frac{1}{2}$ (2)
- 9.3.3 (a) CH₃CH₂CH₂CH₂CHCℓCH₃ OR CH₃CHCℓCH₂CH₂CH₂CH₃ (✓any halogen included ✓on C2; -1 if not 6C atoms) (2)
- (b) ionic bond ✓ (1)
- 9.4.1 C₃H₈ ✓correct number of carbons (2)
- ✓ correct ratio for an alkane (C_nH_{2n+2}) with coe from #C
- 9.4.2 fossil fuels have chemical potential (stored) energy ✓ which releases heat energy ✓ (2)

[18]

TOTAL MARKS: 200