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CRAWFORD SCHOOLS PRELIMINARY EXAMINATION

AUGUST/SEPTEMBER 2023

PHYSICAL SCIENCES: PAPER II

Time: 3 hours

200 marks

MARKING GUIDELINES

Multiple choice

- 1.1 D✓✓(2)
- 1.2 A✓✓(2)
- 1.3 C✓✓(2)
- 1.4 A✓✓(2)
- 1.5 D✓✓(2)
- 1.6 B✓✓(2)
- 1.7 D✓✓(2)
- 1.8 C✓✓(2)
- 1.9 A✓✓(2)
- 1.10 D✓✓(2)

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QUESTION TWO

2.1 The surface area✓ of the calcium carbonate. (1)

2.2 The rate of production of the gas (bubbles) (carbon dioxide) will be greater in test tube A than in test B. ✓✓ (2)

2.3 The powdered calcium carbonate has a larger surface area than the calcium carbonate chips. ✓

Larger surface area means more collisions, and therefore more effective collisions per unit time ✓

This results in a higher rate of reaction in test tube A than in test tube B. ✓(3)

2.4 $n = \frac{m}{M} \checkmark = \frac{0,8}{100 \checkmark} = 0,008 \text{ mol calcium carbonate}$

$n = cV \checkmark = 0,5(0,06 \checkmark) = 0,03 \text{ mol hydrochloric acid}$

0,008 mol of calcium carbonate reacts with 0,016 mol of hydrochloric acid (1:2) ✓

Therefore, HCl is in excess as there are 0,03 mol HCl. ✓ (6)

2.5.1 Increase. ✓ (1)

2.5.2 Decrease. ✓ (1)

2.5.3 Increase. ✓ (1)

2.6

RATE OF PRODUCTION OF CO _{2(g)}	FINAL AMOUNT OF CO _{2(g)} PRODUCED
Remain the same✓	Remain the same✓

(2)

2.7 A bond which occurs between atoms within molecules. ✓✓ (2)

2.8 Calcium chloride ✓ (1)

2.9 Polar covalent bonding ✓

$$\Delta EN = 3,5 - 2,5 = 1,0 \checkmark$$

$\Delta EN > 0 \checkmark$, therefore polar covalent (3)

- 2.10 Water particles are held together by stronger ✓ Hydrogen bonds ✓ whereas carbon dioxide particles are held together by weaker London forces. ✓

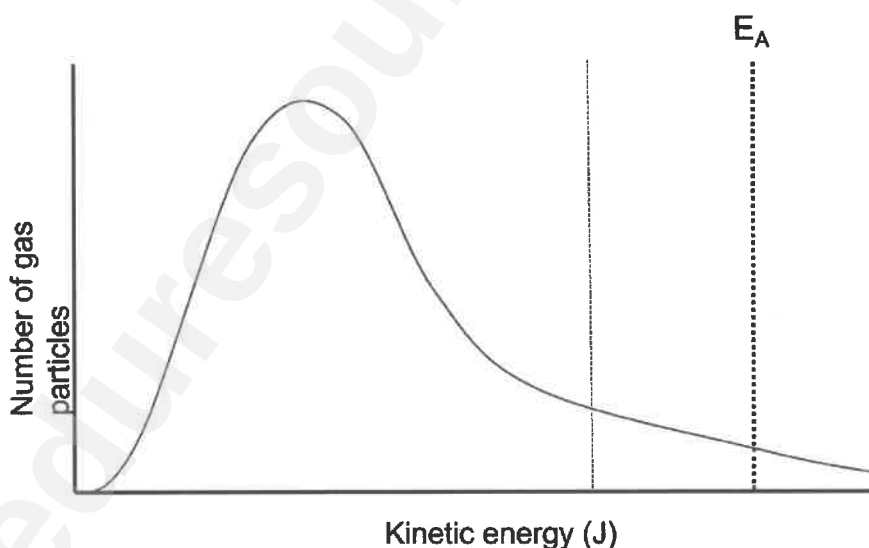
The stronger Hydrogen bonds result in the water particles being held closer to one another ✓ in ice than the carbon dioxide particles in dry ice.

Less energy is required to separate the carbon dioxide particles ✓ (overcome the intermolecular forces between the molecules) than the water particles. (5)

[28]

QUESTION THREE

- 3.1 A reversible reaction is a reaction where the reactants form products and the products can convert back to reactants ✓✓ (2)
- 3.2 A closed system is one in which mass is conserved in the system, but energy can enter or leave the system freely. ✓✓ (2)
- 3.3 average rate = $\frac{\Delta c}{\Delta t} = \frac{8-0}{4-0}$ ✓✓ = 2 mol·dm⁻³·min⁻¹ ✓ (3)
- 3.4 The gradient is initially steeper ✓ for the reaction at 600 K than the reaction at 400 K. (1)
- 3.5 The equilibrium concentration (yield) of methanol decreases as the temperature increases. ✓✓ (2)
- 3.6 Exothermic. ✓
An increase in temperature favours the reverse ✓ endothermic reaction ✓ as this reaction uses the added energy (✓)
This causes the yield of methanol to decrease as temperature increases. (3)
- 3.7 At 520 K the rate of the reaction will be higher than at 400 K ✓, and the yield will be higher than at 600 K. ✓ (2)
- 3.8



- 3.8 E_A line must move left ✓ (2)
- 3.9 Shade in, to the right of the new E_a line. ✓ (1)

[18]

QUESTION FOUR

- 4.1 The heat of reaction is the difference in the potential energy of the products and the reactants. ✓✓

OR

The heat of reaction can be determined by finding the difference between the energy taken in to break the reactant bonds and the energy released when the product bonds form. ✓✓

OR

The net change of the chemical potential energy of the reaction. (2)

- 4.2 $92,4 \text{ kJ} \cdot \text{mol}^{-1}$ ✓ (1)

- 4.3.1 Rate of forward reaction equals the rate of the reverse reaction. ✓ (1)

- 4.3.2 Rate of forward reaction is greater than rate of the reverse reaction. ✓ (1)

- 4.4 The volume of the container decreased so the pressure increased ✓ (1)

- 4.5 Decreased volume/increased pressure results in the forward reaction being favoured. ✓

The forward reaction produces fewer moles of gas. ✓

This can be seen on the graph by the decrease in the concentrations of nitrogen and hydrogen gases (reactants) ✓ and the increase in the concentration of ammonia gas (products) ✓

The yield of ammonia increases. ✓ (5)

- 4.6 $K_c = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3}$ ✓ (2)

- 4.7

	N_2	H_2	NH_3
Ratio	1	3	2
Initial mol	X	$20/2 = 10$ ✓	0
Change in mol ✓ (ratio)	-1	-3	+2
Equilibrium mol ✓ (method)	X-1	7	2
concentration ✓ (/10)	0,1(X-1)	0,7	0,2

$$6,04 = \frac{0,2^2}{0,1(X-1)}$$

$$0,7^3(0,1(X-1))$$

$$X = 1,275 \text{ moles} \quad \checkmark \quad (6)$$

[19]

QUESTION FIVE

5.1.1 P✓ (1)

5.1.2 R✓ (1)

5.1.3 P✓ (1)

5.1.4 Ethanoic acid is a weak acid, so will have a low hydronium ion concentration✓.

Sulphuric acid is a strong, diprotic acid, so its hydronium ion concentration will be higher than that of nitric acid. ✓

The higher the concentration of ions, the better the electrical conductivity✓ (3)

5.2 $\text{CH}_3\text{COOH} + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{COO}^- + \text{H}_3\text{O}^+$ ✓ (2)5.3 CH_3COO^- ✓ (1)5.4 $K_a = \frac{[\text{CH}_3\text{COO}^-][\text{H}_3\text{O}^+]}{[\text{CH}_3\text{COOH}]}$ ✓ (2)

5.5 Low ✓

The concentration of the ions (numerator) will be low ✓ as it is a weak acid. (2)

5.6 phenolphthalein ✓ (1)

5.7 CH_3COO^- ions will react with water to form OH^- ions✓ K^+ ions do not react with water ✓ $[\text{OH}^-] > [\text{H}_3\text{O}^+]$ ✓ at the end point OR $\text{pH} > 7$, so the indicator must change in the alkaline range. ✓ (4)

5.8 It reduces the chances of solution spilling out of the flask during the swirling of the solution. This ensures that the final average volume is more accurate, remains constant. ✓✓ (2)

5.9 pink to colourless ✓ (1)

5.10

Run number	1	2	3
Start volume (cm^3)	4,51	4,15	6,80
End volume (cm^3)	44,39	43,25	49,31
Volume delivered to flask (cm^3)	39,88	39,10	42,51

Must be 2 decimals, no units, all correct (-1 per error) ✓✓✓

Average: 40,50✓ (3)

5.11 $n = cV = 0,06 \checkmark \times 40,50 \times 10^{-3} \text{ (coe)} \checkmark = 0,00243 \text{ mol of ethanoic acid}$

$$c = \frac{n}{v} = \frac{0,00243}{0,03 \checkmark} = 0,081 \text{ mol} \cdot \text{dm}^{-3} \text{ KOH}$$

$$K_w = [\text{H}_3\text{O}^+][\text{OH}^-] = 1 \times 10^{-14} \checkmark = [\text{H}_3\text{O}^+](0,081) \checkmark$$

$$[\text{H}_3\text{O}^+] = 1,23 \times 10^{-13} \text{ mol} \cdot \text{dm}^{-3} \checkmark$$

(6)

[31]

QUESTION SIX

6.1 A substance that can conduct electricity ✓ by forming free ions when molten or dissolved in solution ✓ (2)

6.2 Pure copper ✓ (1)

6.3 Mg atoms in impure Cu are oxidized to Mg^{2+} ions

✓

✓

Pt atoms in impure Cu are weaker reducing agents than Cu and will remain in the sludge

✓

✓

(4)

6.4 5,6 ✓✓ (unit included = 1mark only)

$5,6 \times 10^{-3}$ (1 mark only)

0,0056 1 mark only

(2)

6.5 Heading ✓

Correct label and unit on x-axis ✓

Correct label and unit on y-axis ✓

Correctly plotted points ✓

Best-fit line correctly drawn ✓

Line is extended beyond plotted points and through zero ✓

(6)

6.6 Gradient = $\Delta y / \Delta x$ ✓

$= (37-4) / (12,5 \times 10^{-3} - 1,5 \times 10^{-3})$ ✓

$= 3000 \text{ A/s}^{-1}$ or A.s or C ✓ (must have unit)

(-1 if points not shown on graph)

(3)

6.7.1 $Q = It$ and $Q = nF$ ✓

$I = Q \cdot (1/t)$ because $y = mx + c$

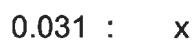
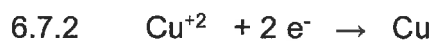
Gradient = $Q = 3000 = nF$

coe ✓

$= n (96500)$ ✓

$n = 0.031 \text{ mol}$ ✓

(4)



$n = m/M$

$0.0155 = m / 63,5 \checkmark$

$m = 0.98\text{g} \checkmark$

(3)

6.8 a. gold or Au $\checkmark$

b. tin or Sn $\checkmark$

c. Au^{3+} or gold ion $\checkmark$

d. Au^{3+} or gold ions $\checkmark$

e. Au or gold $\checkmark$

(5)

[30]

QUESTION SEVEN

7.1 The electrode where oxidation takes place ✓✓ (2)

7.2 Ni is a stronger reducing agent than Ag. ✓

Ni is oxidised. ✓

Oxidation occurs at the anode. ✓

(3)

7.3 $\text{Ni}_{(s)} / \text{Ni}^{2+}_{\text{aq}} (1 \text{ mol.dm}^{-3}) // \text{Ag}^{+}_{\text{aq}} (1 \text{ mol.dm}^{-3}) / \text{Ag}_{(s)}$ at 25°C

✓

✓

✓

All phases ✓

Std conditions ✓

(5)

7.4 $E^{\ominus}_{\text{cell}} = E^{\ominus}_{\text{cathode}} - E^{\ominus}_{\text{anode}} \checkmark = 0,8 - (-0,25) \checkmark = 1,05 \text{ V} \checkmark$

(3)

7.5 Increase ✓

(1)

[14]

QUESTION EIGHT

8.1 Series of similar compounds with same general formula ✓ and same functional group ✓ where each member differs from the previous one by a single CH₂ unit ✓.

(3)

8.2 Alkenes ✓

(1)

8.3 Compound C ✓

(1)

8.4 Butane-1,1- diol

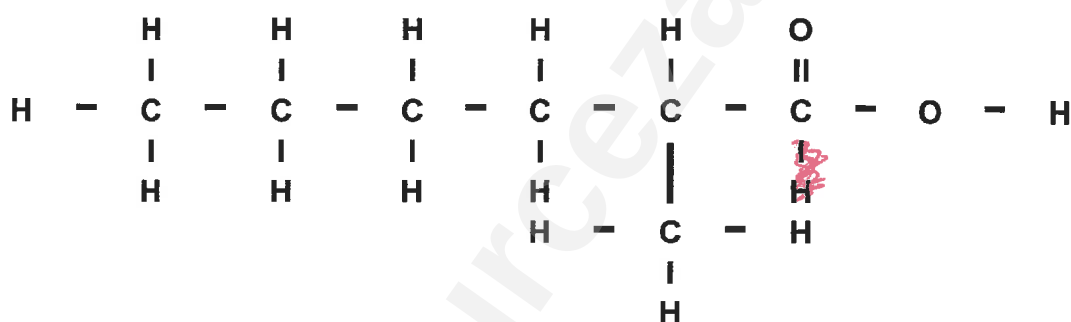
(3)

✓ ✓ ✓

8.5 Hydroxyl ✓

(1)

8.6



6 carbon atoms ✓

Functional group of carboxylic acid ✓

Methyl on carbon 2 ✓

(3)

8.7 ~~heptanoic acid~~ ✓ ✓ *ester 7C.*

(2)

8.8 C_nH_{2n+2} ✓

(1)

8.9 ethanol or ethan-1-ol ✓

pentanoic acid ✓

(2)

8.10 Both have weak London forces ✓

D has 2 sites for hydrogen bonds ✓

D has stronger intermolecular forces due to presence of hydrogen bonds ✓

More energy needed ✓

To separate molecules or overcome intermolecular forces ✓

(5)

[22]

QUESTION NINE

- 9.1.1 Butane ✓✓ (2)
- 9.1.2 Addition ✓ (1)
- 9.1.3 Halogenation ✓ (Chlorination). (1)
- 9.1.4 Ethanol solvent ✓, heat under reflux ✓, concentrated, strong base, absence of water ✓ (any three) (3)
- 9.1.5 $\text{CH}_3\text{CHClCH}_2\text{CH}_3 \checkmark + \text{KOH} \rightarrow \text{CH}_3\text{CHOHCH}_2\text{CH}_3 \checkmark + \text{KCl} \checkmark$ (3)
- 9.1.6 They do have the same functional group or both are alkenes. ✓ *or ✓ same homologous series*
 They do not have same or have different boiling points ✓
 They have different chain lengths/ no. of C atoms ✓ */ surface area* (3)
- 9.2.1 Compound with carbon and hydrogen atoms ✓ only ✓ (2)
- 9.2.2 Cracking ✓ (1)
- 9.2.3 (H atoms are conserved)
 $22 = p + p + 6 \checkmark$
 $p = 8 \checkmark$ (2)

[18]

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