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Grade 12 Physical Science 2024

Preliminary Examination Paper 2 (Memorandum)

Question 1 [20 Marks]

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

Question 2 [12 Marks]

- 2.1 The intramolecular bonding in both diamond and iodine is non-polar ✓ covalent. ✓

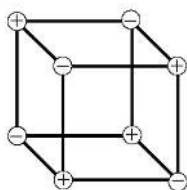
The structure of iodine is molecular ✓

The structure of diamond is giant covalent/network covalent ✓

When iodine melts, little energy is needed to overcome (not break) the weak intermolecular forces (induced dipole / London) between iodine molecules. ✓ Hence, iodine has a low melting point

When diamond melts, much energy is needed to break the many strong covalent bonds. ✓ (Reference to intermolecular forces = contradiction). Hence, diamond has a high melting point. (6)

2.2 Calcium Oxide

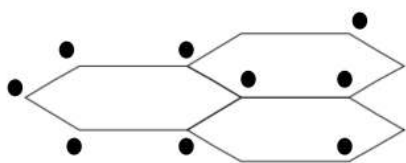


✓

Cations are Ca^{2+}

Anions are O^{2-}

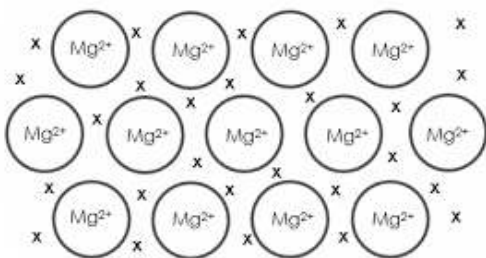
Students may also draw a 2D diagram showing the arrangement of ions in the compound.

Graphite

✓

The diagram should show a plane of hexagons.
The delocalised electrons (dots) may be shown.

Accept a Lewis-dot diagram.

Magnesium

✓

Calcium oxide: CaO has an ionic structure. CaO conducts when molten (or in solution) due to the presence of mobile ions [OR non conductor when solid since no mobile ions] ✓

Graphite: Graphite has a network structure. Graphite can conduct electricity when solid due to the presence of delocalised electrons. ✓

Magnesium: Magnesium has a metallic structure. Mg conducts electricity due to the presence of delocalised electrons. ✓

(6)

Question 3 [8 Marks]

3.1 A measure of the tendency of an atom to attract a bonding pair of electrons. ✓✓ (2)

3.2.1 Liquid F₂: **induced-dipole / London force** ✓
Liquid CH₃F: **dipole-dipole** (not just 'dipole') ✓
Liquid HF: **hydrogen bonding** ✓ (3)

3.2.2 There is a large difference in electronegativity between H (2.1) and F (4.0) atoms ✓

The fluorine atom has at least one pair of electrons. ✓

The fluorine and hydrogen atoms are very small. ✓ (3)

(Student must refer to fluorine and hydrogen. If student talks about hydrogen bonding in general terms, award maximum 2 marks)

Question 4

4.1 Boxes 2 and 4 ✓ (2)

4.2.1 Rate at t_2 less than at t_1 or the rate decreases ✓

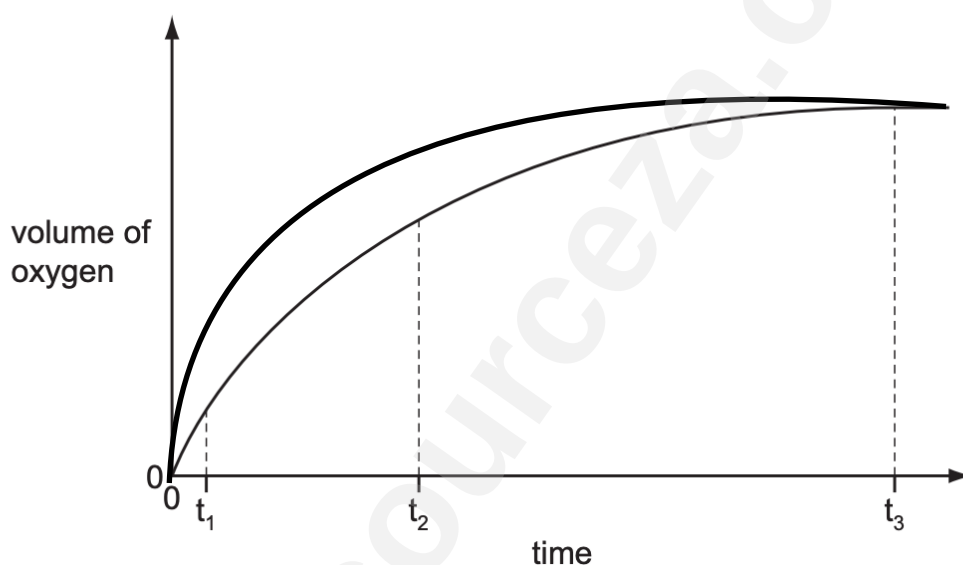
Rate at t_3 zero/reaction stopped ✓ (2)

4.2.2 (as the reaction proceeds) the concentration of hydrogen peroxide decreases ✓

(rate) of successful collision decreases ✓

reaction stops when hydrogen peroxide is used up ✓ (3)

4.3.1



Steeper and must come from the origin ✓ Same volume of oxygen produced ✓ (2)

4.3.2 steeper curve because of a faster rate ✓

faster rate because of increased surface area of catalyst ✓ (which increases the rate of successful collisions)

same volume of oxygen produced because same amount (in mol) of hydrogen peroxide used ✓

(3)

4.4.1 A substance that increases the rate of the reaction but remains unchanged at the end of the reaction. ✓✓ (2)

4.4.2 filter reaction mixture then weigh/measure mass manganese(IV) oxide after reaction ✓

the mass should be 0.1g or unchanged. ✓ (2)

- 4.5 Increasing the concentration of a solution of hydrogen peroxide increases the number of hydrogen peroxide particles per unit volume. ✓

Therefore, more H_2O_2 particles will have energy greater than or equal to the activation energy ✓ and there will be more effective collisions per unit time which increases its reaction rate. ✓

A second curve must be drawn . ✓

(4)

- 4.6 number of moles of O_2 formed = $0.096/22.4 = 0.0043 \text{ mol}$ ✓(1)

number of moles of H_2O_2 in 40cm^3 of solution = $0.0043 \times 2 = 0.0086 \text{ mol}$ ✓(1)

concentration of the hydrogen peroxide in $\text{mol/dm}^3 = 0.0086/0.04 = 0.21 \text{ mol}$ ✓(1)

Question 5

- 5.1 A system in which mass is conserved inside the system ✓, but energy can enter or leave the system freely. ✓ (2)

- 5.2 Forward rate > Reverse rate ✓ (1)

- 5.3 The concentration (or amounts) ✓ of all substances remain constant. ✓ (2)

5.4 $K_c = \frac{[\text{ICl}_3]}{[\text{ICl}][\text{Cl}_2]}$ ✓

$$K_c = \frac{0.4}{(0.2)(0.1)} \text{ ✓(numerator) ✓(denominator)}$$

$$= 20 \text{ ✓} \quad (4)$$

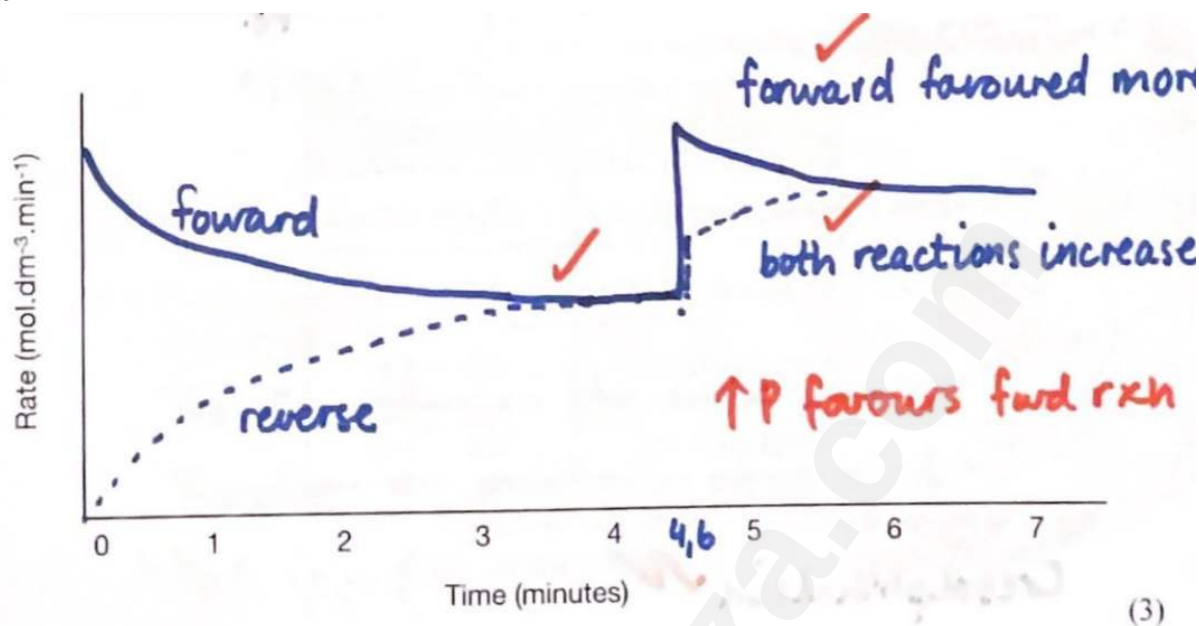
- 5.5 When an external stress (change in pressure, temperature or concentration) is applied to a system in dynamic equilibrium, the equilibrium point will change in such a way as to counteract the stress. ✓✓ (2)

- 5.6 Forward ✓✓ (2)

- 5.7 More yellow or less brown ✓ (don't accept "yellow") (1)

- 5.8 Increase ✓ in pressure ✓ (1)

5.9



- 5.10 An increase in temperature favours the endothermic reaction. ✓
 A decrease in K_c shows that the reverse reaction was favoured. ✓✓
 Thus the reverse reaction is endothermic, forward is exothermic. ✓ (4)

Question 6

6.1.1 Ammonia is a weak base because it is a proton acceptor ✓ and partially **ionises** in water to produce hydroxide ions. ✓ (2)

6.1.2 $\text{HCl} + \text{NH}_3 \rightarrow \text{NH}_4\text{Cl}$ (LHS Species and balanced) ✓ (RHS species and balanced) ✓ (2)
 $\text{NH}_4^+ + \text{Cl}^-$

6.1.3 B ✓
 C ✓
 A ✓ (3)

6.2.1 The point where an acid and base have reacted so neither is in excess. ✓✓ (2)

6.2.2 $\text{pH} = 8.5 \pm 0.5$ ✓ (1)

6.2.3 Thymol blue ✓ (1)

6.2.4 $24 \text{ cm}^3 / 0.024 \text{ dm}^3$ ✓ (1) (subtract mark for no units or incorrect units)

6.2.5 $\text{H}_2\text{X}(\text{aq}) + 2\text{H}_2\text{O}(\ell) \rightleftharpoons \text{X}^{2-}(\text{aq}) + 2\text{H}_3\text{O}^+(\text{aq})$ ✓LHS ✓RHS ✓Balanced
 (ignore phase symbols) (3)

Students may not show the “decomposition” of hydrogen peroxide into its ions, since the question specifically asks students to write an “ionisation” reaction which is a reaction between an acid and water.

6.3.1 First calculate the concentration of hydronium ions in the flask using K_w :

$$K_w = [H_3O^+][OH^-] \checkmark$$

$$1 \times 10^{-14} = [H_3O^+][OH^-] \checkmark$$

$$[H_3O^+] = 5 \times 10^{-4} \text{ mol} \cdot \text{dm}^{-3} \checkmark$$

By the mole ratio the concentration of X^{2-} ions will be half the concentration of hydronium ions (H_3O^+).

$$K_a = \frac{[H_3O^+]^2[X^{2-}]}{[H_2X]} \quad \text{(numerator)} \checkmark \quad \text{(denominator)} \checkmark$$

$$K_a = \frac{(5 \times 10^{-4})^2(2,5 \times 10^{-4})}{(0,34)} \quad \text{(numerator)} \checkmark \quad \text{(denominator)} \checkmark$$

$$K_a = 1,84 \times 10^{-10} \checkmark$$

6.3.2 Diprotic $\checkmark$

6.3.3 The K_a value of the acid is low. $\checkmark$

Therefore, the acid is a weak acid. $\checkmark$

The acid is a poor conductor of electricity. $\checkmark$ (3)

Question 7

7.1 A reaction involving the transfer of electrons. $\checkmark\checkmark$ (2)

7.2 A = Platinum (electrode) $\checkmark$ (Don't accept “electrode”)

B = H^+ (aq) / HCl (aq) / other suitable acid $\checkmark$

C = Voltmeter $\checkmark$

D = Cl_2 (g) / chlorine gas $\checkmark$ (4)

7.3 The salt bridge completes the circuit allowing charges to flow **OR**

The salt bridge maintains electrical neutrality $\checkmark$ (1)

7.4 INCREASE $\checkmark\checkmark$ (1)

7.5.1 $Pt(s) | H_2(g, 1 \text{ atm}) | H^+(aq, 1 \text{ mol} \cdot \text{dm}^{-3}) || Cl_2(g, 1 \text{ atm}) | Cl^-(aq, 1 \text{ atm}) | Pt(s)$ at $25^\circ C$.

$Pt(s)$ must appear at start and end of cell notation $\checkmark$

H_2 (the reducing agent) **and** H^+ (oxidised species) correctly identified $\checkmark$

Cl_2 (the oxidising agent) **and** Cl^- (reduced species) correctly identified $\checkmark$

All standard conditions (including temperature) correctly identified $\checkmark$

All phases correctly identified ✓

Subtract (—1) if symbols for salt bridge (||) and phase boundaries (|) not included or incorrectly used. (5)

7.5.2 Arrow marked on or close to wire via voltmeter pointing from hydrogen half cell to chlorine half cell ✓✓ (2)

7.5.3 (1) An increase in the pressure of the hydrogen gas causes a stress to the system, **OR**
According to Le Chatelier's principle, the system will react to decrease the pressure. ✓
(2) Therefore, the forward reaction of the cell ($\text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightleftharpoons 2\text{HCl}(\text{aq})$) is favoured which produces the fewest number of moles of gas. ✓
(3) This will increase the initial EMF. ✓ (3)

7.6 The standard electrode potential for $\text{ClO}_3^- / \text{Cl}_2$ is more positive than that of $\text{Cl}_2 / \text{Cl}^-$ ✓

ClO_3^- has a greater tendency to gain electrons than Cl_2 ✓

ClO_3^- is a stronger oxidising agent than Cl_2 ✓ (Hence, the emf of $\text{ClO}_3^- / \text{H}_2$ is larger). (3)

Question 8

8.1 A solution of sodium chloride ✓ (1)

8.2 electrical → chemical ✓ (1)

8.3 Sodium ions / Na^+ ✓ (1)

8.4 Water / H_2O ✓ (1)

8.5 Gas A: $2\text{Cl}^- \rightarrow \text{Cl}_{2(\text{g})} + 2\text{e}^-$ (correct half-reaction) ✓ (chlorine gas) ✓ (2)

Gas B: $2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_{2(\text{g})} + \text{OH}^-$ (correct half-reaction) ✓ (hydrogen gas) ✓ (2)

8.6 Sodium hydroxide (aq) / $\text{NaOH}(\text{aq})$ ✓ (1)

8.7 $2\text{Cl}^- + 2\text{H}_2\text{O} \rightarrow \text{Cl}_2 + \text{H}_2 + 2\text{OH}^-$ or $2\text{NaCl} + 2\text{H}_2\text{O} \rightarrow \text{Cl}_2 + \text{H}_2 + \text{NaOH}$
(LHS, correct species and balanced) ✓ (RHS, correct species and balanced) ✓ (2)

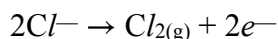
8.8 Water has a standard electrode potential of -0.83V , while sodium ions have a standard electrode potential of -2.71V . ✓

Thus, water is a stronger oxidising agent than sodium ions. ✓

Hence, water undergoes reduction (gains electrons) in preference to sodium ions at the cathode. ✓ (3)

8.9 $Q = It$ ✓ = $(4000)(150) = 600\,000\text{ C}$ ✓

$$n_{\text{e}^-} = \frac{Q}{F} = \frac{600000}{96500} = 6.22 \text{ mol electrons } \checkmark$$



Mole ratio: $\text{Cl}_{2(\text{g})} : 2\text{e}^- = 1:2$, hence $\text{Cl}_{2(\text{g})} = 3.11 \text{ mol}$ ✓

$$V_{\text{Cl}_2} = nV_m \text{ ✓} = (3.11)(22.4) \text{ ✓} = 69.66 \text{ dm}^3 \text{ ✓} \quad (7)$$

Question 9

9.1.1 Alkanes ✓ (1)

9.1.2 $\pm 120 \text{ }^\circ\text{C}$ ✓ (1)

9.1.3 Butane ✓ (1)

9.1.4 All the molecules contain London forces. ✓

As the molecules increase in size, the number of electrons increase resulting in a larger electron cloud and interactive surface. This results stronger London forces. ✓

This causes the boiling points to increase as more energy is needed to overcome the forces between the molecules. ✓ (3)

9.1.5 hexane has a higher boiling point than 2-methylpentane. ✓ (1)

9.2.1 IMPURE ✓

BOILING ✓

DISTILLATION ✓ (3)

9.2.2 combustion ✓ (1)



(LHS Species) ✓ (RHS Species) ✓ (LHS Balanced) ✓ (RHS Balanced) ✓ (4)

9.2.4 Saturated — all the bonds between the carbon atoms in octane are single ✓

Hydrocarbon — octane consists of only carbon and hydrogen atoms ✓ (2)

9.3.1 The cracking of large hydrocarbon molecules requires high temperatures.

In other words, it is an endothermic process because thermal energy is absorbed during the reaction. ✓

The chemical potential energy of the products is greater than that of the reactants. ✓

The change in enthalpy is POSITIVE ✓ (3)

9.3.2 Molecular ✓ (1)

9.3.3 Propane releases thermal energy during oxidation ✓ (1)

9.3.4 Carbon-Carbon double bond ✓ (1)

9.3.5 Red-brown to colourless ✓ (1)

9.3.6 X = pent-1-ene and pent-2-ene

1 mark for naming pent-1-ene **and** pent-2-ene ✓

2 marks for correctly drawing the structural formula for these compounds ✓✓ (3)

9.4 **BALANCED chemical equation:** $\text{CH}_3\text{CH}_3 + \text{Cl}_2 \rightarrow \text{CH}_3\text{CH}_2\text{Cl} + \text{HCl}$ ✓ (2)

GENERAL reaction type: Substitution ✓ (1)

SPECIFIC reaction type: Halogenation ✓ (1)

OXIDISING agent name: Chlorine ✓ (1)

ONE reaction condition: UV light ✓ or Heat ✓ (1)

Question 10

10.1 3-bromo-2,4-dimethylhexane (3-bromo ✓ —2,4—dimethyl✓hex✓ane✓) (4)

10.2 5-methylhexa-1,3-diene (5-methyl✓hexa✓—1,3—di✓ene✓) (4)

10.3 8 carbon atoms, all carbon atoms are saturated ✓

-OH on third carbon atom ✓

Ethyl on third carbon atom and methyl on fourth carbon ✓

Fluorine atoms on 2nd carbon and 4th carbon ✓ (4)

