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PRELIMINARY EXAMINATION 5 SEPTEMBER 2016

PHYSICAL SCIENCES – PAPER 2 (CHEMISTRY)

Time: 3 hours
Examiner: T. Rodrigues

200 marks
Moderator: S. Pillay

MEMORANDUM

QUESTION 1

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

[20]

QUESTION 2

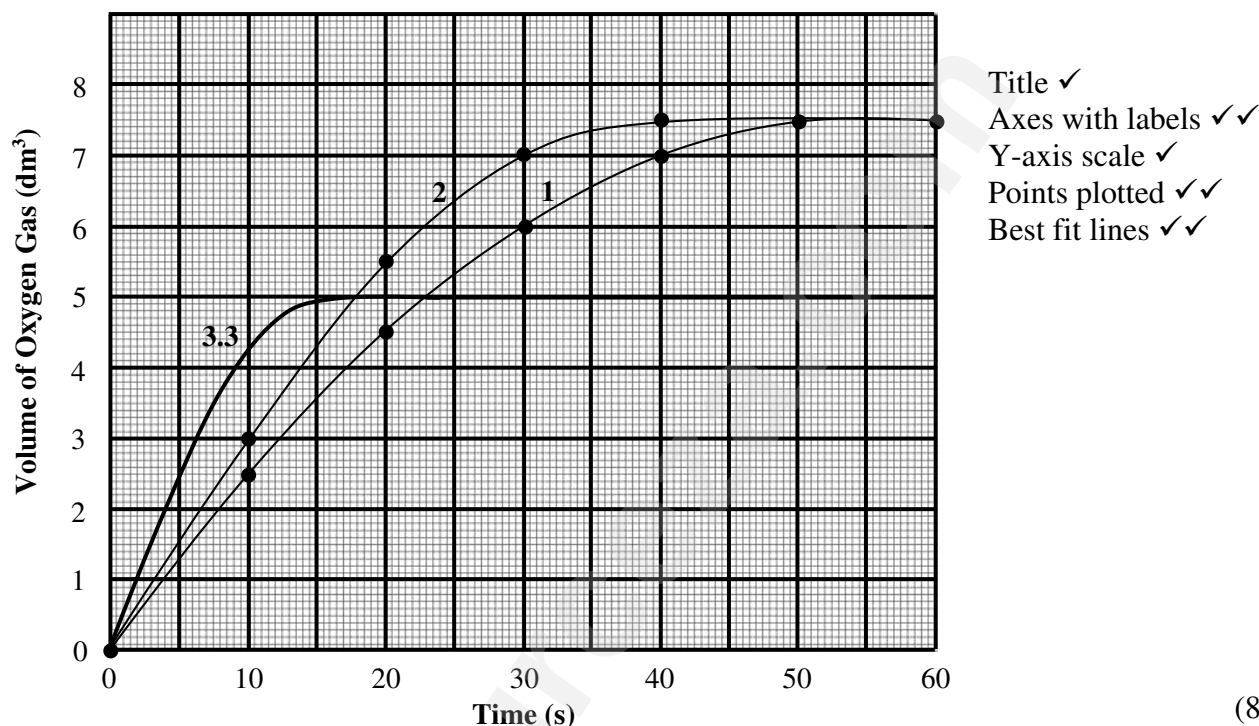
- 2.1
- Substance C ✓
 - The intermolecular forces are strongest ✓
 - Thus more energy is needed to separate the particles ✓
- (3)
- 2.2
- 2.2.1. A, B, and C – solids ✓
- (1)
- 2.2.2. A, B, and C – liquids ✓
- (1)
- 2.3
- 2.3.1.
- B has ionic bonding ✓
 - It cannot conduct in solid form as its ions are fixed in a crystal lattice ✓
 - When molten, the ions are free to move and thus it can conduct ✓
- (3)
- 2.3.2.
- A is a metal (it has metallic bonding) ✓
 - It can conduct in all phases ✓
- (2)
- 2.3.3.
- C has covalent bonding ✓
 - It cannot conduct electricity as it doesn't contain any charged particles ✓
- (2)
- 2.4
- Graphite has a giant covalent lattice/network ✓
 - To separate its particles, you need to break covalent bonds ✓
 - Which are much stronger than the intermolecular forces in A, B, or C ✓
 - Needing much more energy to separate the particles ✓
- (4)

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QUESTION 3

3.1 • $n_{KClO_3} = \frac{m}{M} = \frac{(30)}{(122,5)} = 0,2449 \text{ mol} \checkmark$
 • $n_{O_2} = n_{KClO_3} \times \frac{3}{2} = (0,2449) \times \frac{3}{2} \checkmark = \mathbf{0,37 \text{ mol} \checkmark}$ (3)

3.2 Graph Showing the Relationship between Volume of Oxygen Gas and Time at 30 °C and 40 °C



3.3 ✓ Steeper gradient (8)
 ✓ Final volume = 5 (2)

3.4 $\left. \begin{array}{l} 1 - 50 \text{ s} \\ 2 - 40 \text{ s} \end{array} \right\} \checkmark$ (1)

3.5 • A higher temperature means the average kinetic energy of the particles is greater ✓
 • The faster moving particles result in a higher frequency of collision ✓
 • Also, and more importantly, there is a greater proportion of particles with a kinetic energy greater than the activation energy ✓
 • Both of these factors increases the chance of effective collisions ✓
 • Thus the reaction rate is higher ✓ (5)

3.6 $n_{actual} = \frac{V}{V_m}$
 $n_{actual} = \frac{(7,5)}{(22,4)} \checkmark$
 $n_{actual} = 0,3348 \text{ mol} \checkmark$
 $\% \text{ Yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$
 $\% \text{ Yield} = \frac{(0,3348)}{(0,37)} \times 100 \checkmark$
 $\% \text{ Yield} = \mathbf{90,49 \%} \checkmark$ (4)

3.7 $\text{Rate} = \frac{\Delta V}{\Delta t} \checkmark$
 $\text{Rate} = \frac{(7,5-0)}{(40)} \checkmark$
 $\text{Rate} = \mathbf{0,19 \text{ dm}^3 \cdot \text{s}^{-1} \checkmark}$ (3)

3.8 The gradient ✓ of the tangent ✓ to the curve at that point (OR the derivative of the graph at that point) will be equal to the instantaneous reaction rate. (2)

QUESTION 4

4.1 Reactants (ICl_3) ✓ (1)

4.2 $K_c = \frac{[\text{I}_2][\text{Cl}_2]^3}{[\text{ICl}_3]^2}$ ✓✓ (2)

4.3 Concentrations:

R	2ICl_3	$\rightleftharpoons$	I_2	+	3Cl_2
I	$c = \frac{m}{MV}$ $c = \frac{(163,5)}{(233,5)(2)}$ $c = 0,3501$ ✓		0		0
C	-0,3		+0,15		+0,45
E	0,0501		0,15		0,45

✓✓

$$K_c = \frac{[\text{I}_2][\text{Cl}_2]^3}{[\text{ICl}_3]^2}$$

$$K_c = \frac{(0,15)(0,45)^3}{(0,0501)^2}$$

$$K_c = 5,45$$

(6)

4.4 A system where either matter or energy is exchanged with the environment. ✓✓ (2)

4.5 Increase ✓ (1)

- 4.6
- Stress: increase in temperature
 - Both reaction rates initially increase ✓
 - But the forward reaction rate increases more as it is endothermic ✓
 - Thus the forward reaction will be favoured ✓
 - Therefore the amount of products will increase and reactants decrease ✓
 - intensifying the brown colour ✓

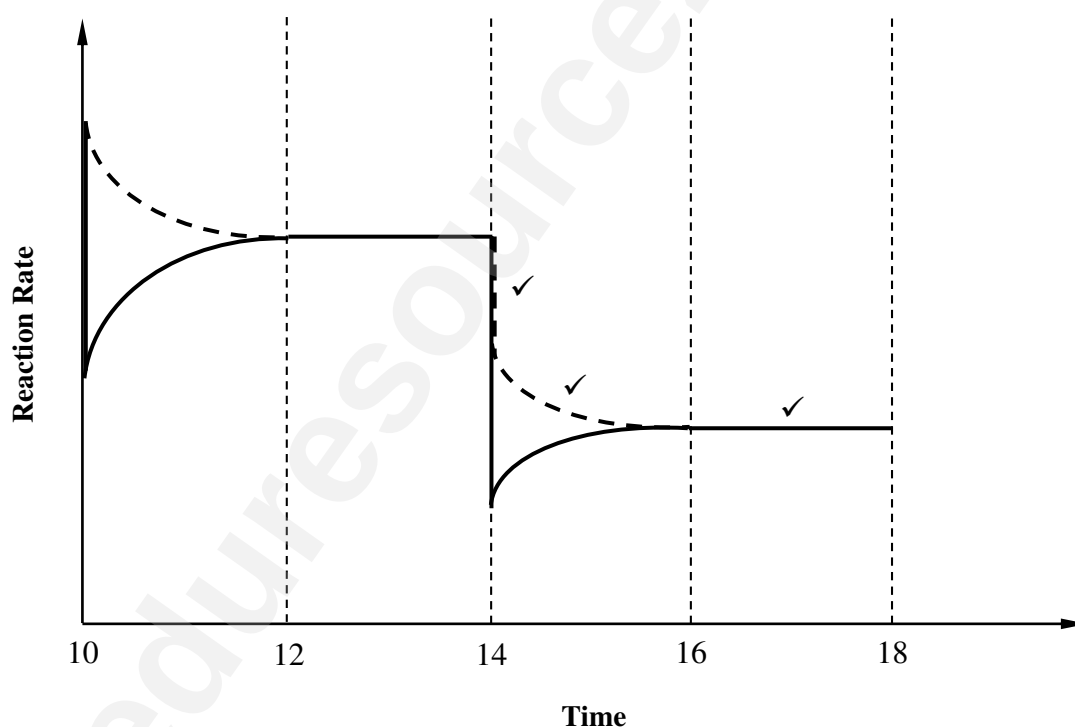
(5)

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QUESTION 5

- 5.1 They are equal ✓ (1)
- 5.2 When an external stress (change in pressure, temperature or concentration) is applied to a system in chemical equilibrium, the equilibrium point will change in such a way as to counteract the stress. ✓✓ (2)
- 5.3
- From the graph, we can see that the concentration of the products decreased and that of the reactants increased ✓
 - Thus, the reverse reaction was favoured ✓
 - The reverse reaction is endothermic, which consumes heat, decreasing the temperature ✓
 - Which, according to Le Châtelier's principle, is the response to an increase in temperature ✓ (4)
- 5.4
- The concentration changes would be the same ✓
 - The changes would occur over a shorter time period ✓ (2)
- 5.5 CO was removed ✓ (1)
- 5.6 A decrease in pressure ✓ (1)

5.7



(3)

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QUESTION 6

- 6.1 A base that dissociates almost completely in an aqueous solution. ✓✓ (2)
- 6.2 Ethanoic acid ✓ (1)
- 6.3
- 6.3.1. A substance in which the hydrogen of an acid has been replaced by a cation. ✓✓ (2)
- 6.3.2. Sodium acetate (or sodium ethanoate) ✓ (1)
- 6.3.3. The point where an acid and base have reacted so neither is in excess. ✓✓ (2)
- 6.3.4. Alizarin yellow ✓ (1)
- 6.3.5.
- $\text{CH}_3\text{COO}^- + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{COOH} + \text{OH}^-$ ✓
 - The Na^+ ions do not hydrolyse water as the NaOH that would result is a strong base and would be completely dissociated in solution ✓
 - The CH_3COO^- ions do hydrolyse water as the CH_3COOH that results is a weak acid and only partially ionized in water ✓
 - Thus an excess of OH^- ions result, and thus a basic solution ✓ (4)
- 6.4 A solution of known concentration. ✓✓ (2)
- 6.5
- $$c = \frac{m}{MV} \quad \checkmark$$
- $$(2,5) = \frac{(75)}{(60)V} \quad \checkmark \checkmark$$
- $$V = 0,5 \text{ dm}^3 \quad \checkmark \quad (4)$$
- 6.6
- $n_a = c_a V_a = (2,5)(0,05) = 0,125 \text{ mol} \quad \checkmark$
 - $n_b = n_a = 0,125 \text{ mol} \quad \checkmark$
 - $c_b = \frac{n_b}{V_b} = \frac{(0,125)}{(0,08315)} \quad \checkmark = 1,5 \text{ M} \quad \checkmark$
- % accuracy = $\frac{(1,5)}{(1,8)} \times 100 \quad \checkmark$
 % accuracy = **83,33 %** ✓ (6)

[25]

QUESTION 7

7.1

7.1.1. **C (OR F)** ✓ (1)

7.1.2. **B (OR E)** ✓ (1)

7.1.3. **E** ✓ (1)

7.2

7.2.1. 2,3-dimethylpent-2-ene ✓✓ (2)

7.2.2. 2-bromo-3-methylpentane ✓✓ (2)

7.2.3.
$$\begin{array}{c} \text{H} \\ | \\ \text{H}-\text{C}=\text{C}-\text{C}-\text{H} \\ | \quad | \quad | \\ \text{H} \quad \text{H} \quad \text{H} \end{array} \quad \checkmark$$
 (1)

7.3 Compounds having the same molecular formula but different structural formulae. ✓✓ (2)

7.4 **A (OR hexanoic acid)** ✓ (1)

7.5

$$\begin{array}{c} \text{H} \\ | \\ \text{H}-\text{C}-\text{H} \\ | \quad | \\ \text{H} \quad \text{H} \\ | \quad | \quad | \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{O}-\text{H} \\ | \quad | \quad | \\ \text{H} \quad \text{H} \quad \text{H} \end{array} \quad \checkmark\checkmark$$
 (2)

7.6

$$\begin{array}{c} \text{H} \\ | \\ \text{H}-\text{C}=\text{C}-\text{C}-\text{H} \\ | \quad | \quad | \\ \text{H} \quad \text{H} \quad \text{H} \end{array} \quad \checkmark\checkmark$$
 (2)

7.7

- Compound B has hydrogen bonds and compound F has London forces ✓
- Hydrogen bonds are stronger than London forces ✓
- Thus, more energy is needed to separate the particles in compound B ✓
- Therefore, compound B has the highest boiling point ✓

(4)

[19]

QUESTION 8

- 8.1 I – addition ✓
III – elimination ✓
IV – substitution ✓ (3)
- 8.2 I – H₂ ✓
IV – concentrated KOH (OR NaOH) ✓ (2)
- 8.3 Platinum (OR palladium OR nickel) ✓ (1)
- 8.4 $2\text{C}_2\text{H}_6(\text{g}) + 7\text{O}_2(\text{g}) \rightarrow 4\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l})$ ✓✓ (2)
- 8.5 • It is important for the combustion of fuel for energy and transportation ✓
• The reaction is highly exothermic and releases large amounts of energy ✓ (2)
- 8.6 $\text{CH}_3\text{CH}_2\text{Br} + \text{KOH} \rightarrow \text{CH}_2\text{CH}_2 + \text{KBr} + \text{H}_2\text{O}$ ✓✓✓✓ (4)

[14]

QUESTION 9

- 9.1
- **Temperature** of 25 °C ✓
 - **Concentration of Cl^-** of 1 mol·dm⁻³ ✓
 - **Pressure of Cl_2 gas** of 1 atm ✓
- (3)
- 9.2 Platinum electrode (NOTE that neither Cl^- nor Cl_2 can be an electrode) ✓
- (1)
- 9.3 $\text{Cr} \rightarrow \text{Cr}^{3+} + 3\text{e}^-$ ✓✓
- (2)
- 9.4 $2\text{Cr(s)} + 3\text{Cl}_2(\text{g}) \rightarrow 2\text{Cr}^{3+}(\text{aq}) + 6\text{Cl}^-(\text{aq})$ ✓✓✓
- (3)
- 9.5 Cr ✓
- (1)
- 9.6 It is inert and conductive. ✓
- (1)
- 9.7
- $$E_{\text{cell}}^0 = E_{\text{cathode}}^0 - E_{\text{anode}}^0 \quad \checkmark$$
- $$E_{\text{cell}}^0 = (+1,36) - (-0,74) \quad \checkmark$$
- $$E_{\text{cell}}^0 = 2,1 \text{ V} \quad \checkmark$$
- (3)
- 9.8
- Stress: increase in concentration of Cr^{3+} ✓
 - Le Châtelier's principle predicts the system will respond in order to decrease the concentration of Cr^{3+} ✓
 - Thus, the reverse reaction will be favoured (as it consumes Cr^{3+}) ✓
 - Decreasing the cell potential ✓
- (4)
- 9.9
- A saturated solution used in the salt bridge increases the conductivity of the salt bridge ✓
 - Thus, lowering the internal resistance of the cell ✓
- (2)
- 9.10
- The chromium electrode would corrode (lose mass) ✓
 - The green colour of the electrolyte would intensify ✓
- (2)

[22]

QUESTION 10

- 10.1 Bayer process ✓ (1)
- 10.2 Cryolite ✓
 Na_3AlF_6 ✓ (2)
- 10.3 • Aluminium oxide (Al_2O_3) has an extremely high melting point ✓
 • This would make the electrolysis difficult and expensive ✓
 • The cryolite lowers the melting point substantially ✓ (3)
- 10.4 Cathode ✓ (1)
- 10.5 $\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}$ ✓✓ (2)
- 10.6 It sinks as shown and is pumped out through a drainage pipe. ✓ (1)
- 10.7 • The oxide (O^{2-}) ions are oxidised to form molecular oxygen ✓
 • This oxygen gas reacts with the carbon anode at this high temperature, forming carbon dioxide gas ✓ (2)
- 10.8 The anode corrodes and is consumed ✓✓ (2)
- 10.9 • Al^{3+} is a much stronger oxidising agent than Na^+ (due to its much more positive electrode potential) ✓
 • Thus, Al^{3+} preferentially reduces as opposed to Na^+ ✓
 • This is despite the greater concentration of Na^+ ions, as the strengths are vastly different ✓ (3)
- 10.10 • $n_{\text{Al}} = \frac{m}{M} = \frac{(1\,264\,000)}{(27)} \checkmark = 46\,814,8148 \text{ mol } \checkmark$
 • $n_{\text{e}^-} = 3 \times n_{\text{Al}} = 3 \times (46\,814,8148) = 140\,444,4444 \text{ mol } \checkmark$
 • $Q = nF = (140\,444,4444)(96500) = 13\,552\,888\,888,8889 \text{ C } \checkmark$
 • $I = \frac{Q}{\Delta t} = \frac{(13\,552\,888\,888,8889)}{(24 \times 3600)} \checkmark = \mathbf{156\,862,14 \text{ A } \checkmark}$ (6)
- 10.11 This extra electrical energy is needed to keep the electrolyte molten. ✓✓ (2)

[25]**Total: 200 Marks**