**SEC 4 EXPRESS – CHEMISTRY 6092 PRELIM EXAM 2023 – ANSWERS**

**Paper 1 – MCQ**

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|---|---|---|---|---|---|---|---|
| 1 | B | 11 | A | 21 | B | 31 | C |
| 2 | C | 12 | C | 22 | C | 32 | D |
| 3 | B | 13 | B | 23 | B | 33 | A |
| 4 | B | 14 | A | 24 | C | 34 | B |
| 5 | B | 15 | C | 25 | D | 35 | B |
| 6 | C | 16 | C | 26 | D | 36 | C |
| 7 | B | 17 | A | 27 | C | 37 | C |
| 8 | C | 18 | D | 28 | A | 38 | B |
| 9 | A | 19 | B | 29 | B | 39 | A |
| 10 | D | 20 | C | 30 | D | 40 | B |

**Paper 2 – Section A – Structured Questions**

| No | Suggested Answers | Marks |
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| A1(a) | (i) D<br>(ii) B<br>(iii) A<br><br>*In general, part (i) and (iii) are not done well. Most students did not relate metal with low melting point as group I element.* | [3] |
| A1(b) | **E** has **achieved stable noble gas configuration / full valence shell of electrons**. [1/2]<br>Hence, **E does not have to gain, lose or share electrons**. [1/2]<br><br>*Most students find it challenging to relate why atom reacts as "gain/lose or share" electrons.* | [1] |
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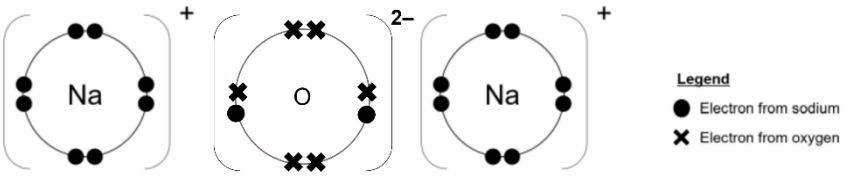
| A2(a) | Carbon dioxide has a **simple molecular structure** [1/2] where **discrete molecules are held together by weak intermolecular forces of attraction** [1/2]. **Little amount of energy** is required to **overcome** these **forces** [1/2].<br><br>Silicon dioxide has a **giant molecular structure** [1/2] where **atoms are held together by strong covalent bonds** [1/2]. **Large amount of energy** is required to **break** these **bonds** [1/2].<br><br>Hence, **carbon dioxide has a lower melting point than silicon dioxide**.<br>*(Minus ½ if this point is missing)* | [3] |
| A2(b) | (i)<br>  <br><br><br>Correct number of charges for each ion – [1]<br>Correct valence electrons drawn for each ion – [1]<br><br>(ii) $Na_2O$ **contains ionic bonds / involves transfer of electrons from Na to O** [1/2] where **oppositely charged ions are held together by strong electrostatic forces of attraction** [1/2].<br><br>Common error: atoms instead of ions are mentioned for $Na_2O$.<br><br>$Cl_2O$ **involves sharing of valence electrons** [1/2] where **atoms are held together by strong covalent bonds** [1/2].<br><br>Accept: **contains covalent bonds** (alternative for marking point on "sharing of valence", if students did not mention "atoms are held together by strong covalent bonds" | [4] |

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| | Most students compare differences in structure which is not required in the question. | |
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| **A3(a)** | **(i) T: <u>iron(II) chloride</u>**<br>**(ii) U: <u>carbon dioxide</u>**<br>**(iii) V: <u>iron(II) hydroxide</u>**<br>**(iv) W: <u>silver chloride</u>**<br><br>*Also accept chemical formulae* | **[4]** |
| **A3(b)** | Mixture **S** likely contains **<u>iron(II)</u>**, **<u>carbonate</u>** and **<u>nitrate</u>** ions.<br>*All three ions must be correct.*<br>*Also accept formulae of ions: $Fe^{2+}$, $CO_3^{2-}$, $NO_3^-$*<br>*Reject: chloride (could have come from hydrochloric acid)* | **[1]** |
| **A3(c)** | $CO_2 + Ca(OH)_2 \longrightarrow CaCO_3 + H_2O$<br>$Fe^{2+}(aq) + 2OH^-(aq) \longrightarrow Fe(OH)_2(s)$<br>$Ag^+(aq) + Cl^-(aq) \longrightarrow AgCl(s)$<br>$CO_3^{2-}(aq) + 2H^+(aq) \longrightarrow CO_2(g) + H_2O(l)$<br><br>*Accept any of the above or any other possible reactions.*<br>Common error: incorrect formulae of silver chloride, iron(II) nitrate etc | **[1]** |
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| **A4(a)** | **<u>Repeat the experiment with known titre value without adding indicator</u>** [1/2] *Also accept answer if students wrote the procedures with values indicated (e.g. 25.0 $cm^3$ of LiOH added to…)*<br><br>**<u>Heat the mixture until a saturated solution is formed</u>**. [1/2]<br>**<u>Cool</u>** the **<u>solution for crystals to form</u>**. [1/2]<br>**<u>Filter</u>** the mixture to obtain the crystals. **<u>Dry</u>** the crystals between sheets of filter paper. [1/2] | **[2]** |
| **A4(b)** | Magnesium hydroxide is **<u>sparingly soluble / insoluble in water</u>**. / It is **<u>difficult to determine the end-point of the neutralisation</u>** (when magnesium hydroxide exists as a solid). OR<br><br>**<u>Mixture that is formed may contain excess acid</u>**. [1]<br>Reject: reaction between magnesium hydroxide and acid is reactive/unsafe. | **[1]** |
| **A4(c)** | Moles of hydrochloric acid<br>= 2.70 x (22.50/1000)<br>= **<u>0.06075 mol</u>** ---------- [1]<br><br>Since hydrochloric acid and lithium hydroxide reacts in 1:1 ratio,<br>moles of lithium hydroxide = 0.06075 mol<br><br>Concentration of lithium hydroxide<br>= 0.06075 ÷ (25/1000)<br>= **<u>2.43 mol/$dm^3$</u>** ---------- [1] | **[2]** |

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| **A5(a)** | Both melting points and boiling points of elements **increase** [1/2] down Group VII.<br><br>Down Group VII, the **intermolecular forces of attraction increases** [1/2] as the **molecular size of halogen increases** [1/2]. Hence, a **larger amount of energy** is required to **overcome** these forces of attraction. [1/2]<br><br>misconception: students relate the increase in mp/bp to within the atom itself, where a larger amount of energy is required to overcome electrostatic forces of attraction between nucleus and valence electron (down the group) | **[2]** |
| **A5(b)** | (i) **Fluorine / chlorine** [1],<br>as **they are more reactive than bromine** [1/2], and **can displace bromine from its aqueous solution** [1/2].<br><br>(ii) **$F_2(aq) + 2Br^-(aq) \longrightarrow Br_2(aq) + 2F^-(aq)$** OR<br>**$Cl_2(aq) + 2Br^-(aq) \longrightarrow Br_2(aq) + 2Cl^-(aq)$** [1]<br><br>*not penalised for missing /incorrect state symbols in this exam* | **[3]** |
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| **A6(a)** | 1. transition elements exhibit **variable oxidation states in their compounds / form compounds that have variable oxidation states** [1]<br>2. transition elements can **form coloured compounds** [1] | **[2]** |
| **A6(b)** | (i) **CuO gained electrons and reduced to form $Cu_2O$** OR **$Cu^{2+}$** in CuO **gained electrons and reduced to form $Cu^+$** in $Cu_2O$. [1]<br><br>(ii) The **oxidation state of oxygen in CuO increases from -2 in CuO to 0 in $O_2$**. [1] | **[2]** |
| **A6(c)** | **(i) Blue solution turned green / pale green** [1/2]<br>*(not colourless)*<br>**Reddish-brown / pink deposits can be observed**. [1/2]<br><br>**Iron is more reactive than copper**, [1/2] hence **iron will displace copper from its aqueous solutions**. [1/2]<br><br>**$Fe + CuSO_4 \longrightarrow FeSO_4 + Cu$** [1]<br><br>(ii) **Electrolysis / using electricity**. [1] | **[4]** |
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| **A7(a)** | An **electrolytic cell** converts **electrical energy to chemical energy**, [1/2] while a **simple chemical cell** converts **chemical energy to electrical energy**. [1/2]<br><br>An **electrolytic cell requires batteries / electric cells**, [1/2] while a **simple chemical cell requires a continuous supply of reactants**. [1/2]<br>Reject: simple cell does not require batteries | **[2]** |
| **A7(b)** | **(i)** cathode: **$Cu^{2+}(aq) + 2e^- \longrightarrow Cu(s)$** [1] no state symbol minus ½<br>**(ii)** anode: **$4OH^-(aq) \longrightarrow 2H_2O(l) + O_2(g) + 4e^-$** [1]no state symbol minus ½ | **[2]** |
| **A7(c)** | Accept any two observations below [1/2 mark each]:<br>- **Effervescence** could be observed at the **anode**<br>- **Reddish-brown/pink deposits** could be observed at the **cathode / cathode increases in size**<br>- **Blue electrolyte turns colourless**<br><br>Accept any two matching explanation [1/2 mark each]:<br>- **hydroxide ions are discharged at the anode to form oxygen gas**<br>- **copper(II) ions are discharged at the cathode to form copper metal**<br>- **concentration of copper(II) ions decreases**<br><br>**Common error: students did not EXPLAIN the observations as stated in the question** | **[2]** |
| **A7(d)** | **Zinc could have reacted with water** in the aqueous copper(II) nitrate to **form hydrogen gas**.<br><br>This question is poorly attempted. Candidates are not sensitise to the occurrence of side reaction (e.g. between metal and water to produce hydrogen gas as one of the products)<br><br>Common error:<br>- zinc is above hydrogen and hence hydrogen is preferentially discharged. note that this is not possible when zinc is the ANODE, which will be oxidised.<br>- hydroxide ions are discharged at anode (not possible as anode is ZINC/reactive electrode) | **[1]** |

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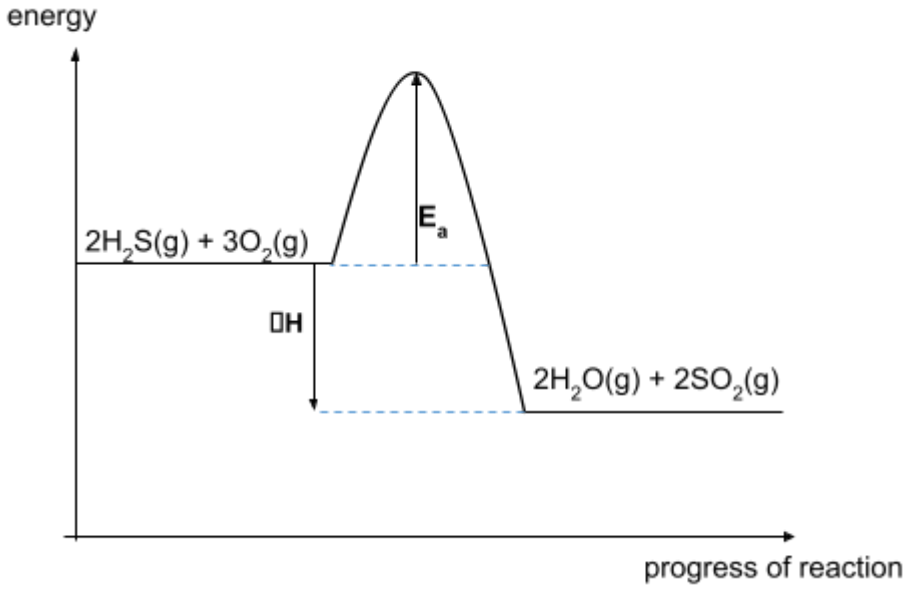
| **A8(a)** | **(i) Marker to note: to mark strictly for the ARROW. Students are advised to use a ruler to draw their lines. Some students did not draw vertical straight line and/or horizontal line that should be parallel to both y-axis and x-axis respectively.**<br>  <br><br>correct profile of diagram – [1]<br>label reactants and products – [1]<br>label enthalpy change and activation energy correctly – [½ x 2]<br><br>(ii) The **amount of energy required to break bonds in hydrogen sulfide and oxygen** is **less than** the **amount of energy released to form bonds in water and sulfur dioxide**.<br><br>correct comparison in terms of amount of energy – [1]<br>correct identification of the bonds to break / bonds to form – [1] | **[5]** |

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| **A8(b)** | Total energy required for bond breaking<br>= (2 x 2 x 364) + (3 x 498)<br>= **<u>2950 kJ</u>** ---------- [1]<br><br>Total energy released during bond forming<br>= (2 x 2 x 464) + (2 x 2 x **X**)<br>= **<u>(1856 + 4X) kJ</u>** ---------- [1]<br><br>Enthalpy change of the reaction = –1034 kJ<br>+2950 – 1856 – 4**X** = –1034 kJ<br>+1094 – 4**X** = -1034 kJ<br>**X** = **<u>532 kJ</u>** ---------- [1]<br>*Also accept X = 532 kJ/mol*<br><br>*Allow e.c.f. for total energy calculated for bond breaking and bond forming.*<br><br>*Some candidates find it challenging to count the number of bonds to break/form, and should have made reference to the balanced chemical equation given. Some students mixed up the signs (+/-) required during calculation for enthalpy change for bond breaking (+) and enthalpy change for bond forming (-).* | **[3]** |

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**Paper 2 – Section B**

| No | Suggested Answers | Marks |
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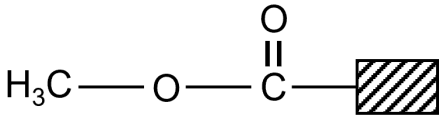
| **B9(a)** | (i) Biofuel is carbon neutral as there is **no net gain/loss in the amount of carbon** released to the environment [1]<br><br>Biofuel **contains carbon that comes from biomass of animals/ the uptake of carbon dioxide by plants** [½] during photosynthesis, and **releases carbon in the form of carbon dioxide during the combustion of biofuel**. [½]<br><br>*Most candidates have no concept of the carbon cycle. A large number relates 'neutral' to 'neither acidic nor alkaline' instead of 'no net gain/loss in carbon'*<br><br>(ii) Process **1** should include processes to **remove any acid impurities** before transesterification process. [1] | **[3]** |
| **B9(b)** | (i) Transesterification is the **reaction between fats/ oils/ esters** (NOT carboxylic acid) **and alcohols** [1/2] **to form esters/ biodiesel and glycerol/alcohol**, [1/2] in the presence of catalyst. *(not insisted)*<br><br>*reject: when students copy directly from the question info*<br><br>(ii) Vegetable oils are called tri-esters as there are **three ester linkages** (accept: 3 ester 'functional groups') [1/2] present **per molecule**. [1/2]<br><br>*Also accept: three fatty acids linked to one glycerol per molecule*<br><br>*reject: one molecule of vegetable oil can form 3 ester molecules*<br><br>(iii) Structure of one molecule of biodiesel:<br><br>  <br><br>*Also accept if full displayed structural formula is shown*<br>Correctly drawn one ester linkage – [1]<br>All other atoms – [1] | **[4]** |
| **B9(c)** | Presence of acid in the waste vegetable oil will **inactivate / make the catalyst ineffective / neutralise / remove KOH**. [1] | **[2]** |

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| | This **slows down / reduces the speed of reaction**. [1] Therefore, longer time is required for its conversion.<br><br>Also accept: acid reacts with the alcohol (i.e. methanol), hence there is less methanol presence to react with vegetable oils to form biodiesel. | |
| **B9(d)** | **Fermentation is a slow process**, [1] requiring specific conditions (i.e. yeast, glucose solution, temperature of 37°C, absence of oxygen) | **[1]** |
| **B9(e)** | Yes, biofuel is a better source of fuel than fossil fuel. *(no mark is awarded without justification)*<br><br>This is because **biofuel is biodegradable** [1/2] when released into the environment (e.g. oil spill) and **produces less air pollutants** [1/2] as it is less likely to be involved in incomplete combustion compared to fossil fuel. *Also accept: renewable compared to fossil fuel [max ½]*<br><br>However, **biofuel produces less amount of energy per mass of fuel** [1/2] compared to fossil fuel and requires crops to be grown for fuel implying that **more energy is involved in the production process**. [1/2]<br>*To also justify on why biofuel is not a better source of fuel than fossil fuel*<br><br>*To reject: "more crops to be grown for fuel" as students should unpack the implication.*<br>*To reject: "take a shorter time to form"; time factor does not make a fuel good or bad.* | **[2]** |
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| **B10(a)** | (i) - **differ from the next member by a $-CH_2$ group**<br><br>- contain the **same functional group**<br>- show **trend in physical properties** (down the series)<br>(reject: different physical properties)<br>- **similar chemical properties** (within the series)<br>*(accept any two) – [2]*<br><br>(ii) Test: To a portion of the sample, **add aqueous bromine / bromine water**. [1] (minus ½ if aqueous is not stated)<br>*note: students need to describe the test*<br>*(reject: bromination)*<br><br>Result: **Reddish-brown** aqueous bromine/ bromine water [1/2] **decolourises/turns colourless** [1/2] | **[4]** |
| **B10(b)** | Both methyne and methene contains carbon-carbon triple bond and carbon-carbon double bond respectively.<br><br>**At least two carbon atoms are required** [1] to form its respective triple/double bond. | **[1]** |
| **B10(c)** | **(i) phosphoric(V) acid** [1] | **[3]** |

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| | (ii) **oxidation** is involved. [1]<br><br>**acidified potassium manganate(VII) / acidified potassium dichromate** [1] (minus ½ if acidified is not stated)<br><br>*reject: oxygen gas from the atmosphere* | |
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| **Either** | | |
| **B11(a)** | Atom economy<br>= (3 x 2) ÷ (28 + 6) x 100%<br>= 17.647<br>= **17.6 % (3 sig.fig)** ---------- [1]<br><br>Correct $M_r$ of useful product determined – [1/2]<br>Correct $M_r$ of products determined – [1/2] | **[2]** |
| **B11(b)** | Increasing the pressure **will not increase the equilibrium yield of hydrogen** [1/2] but **increase the rate of formation of hydrogen**. [1/2]<br><br>Only the **number of particles per unit volume will increase**, [1/2] leading to a **higher frequency of collisions and higher frequency of effective collisions**. [1/2]<br><br>The **total number of particles present in the reaction remains the same**. [1] (Many missed this point) | **[3]** |
| **B11(c)** | (i) 63 / 28 = **2.25 times greater** [1]<br>(Many gave an integer value)<br>(ii) A lower temperature implies that the **rate of reaction will be slower**, [1] and a higher pressure is **more costly/ more difficult to maintain** [1]. | **[3]** |
| **B11(d)** | The demand for ammonia has increased as **more fertilisers are required for agriculture**, [1] and **for various industrial applications like making of plastics, explosives, and synthetic fibres**. [1]<br><br>*(at least two reasons)*<br><br>(rej: lab requires aqueous ammonia) | **[2]** |

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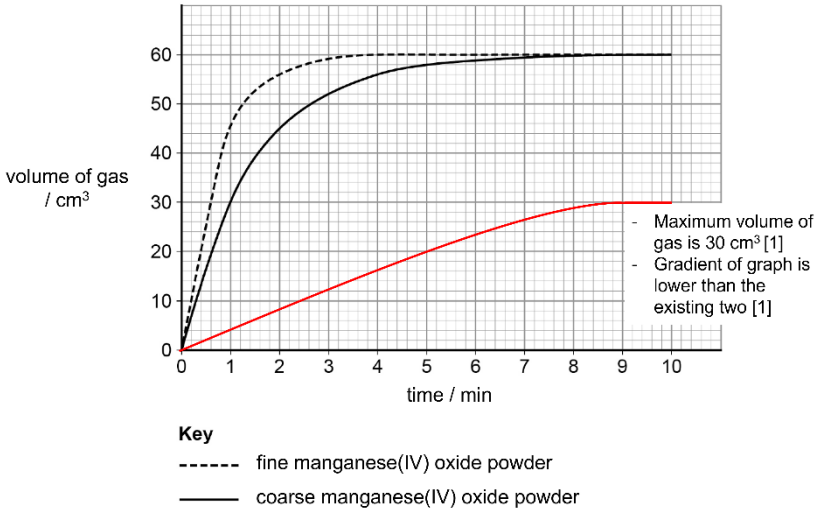
| **Or** | | |
| **B11(a)** | **2**$H_2O_2$ (**aq**) ⟶ **2**$H_2O$ (*l*) + **1**$O_2$ (g)<br><br>*Also accept if coefficient for oxygen gas is left empty* | **[1]** |
| **B11(b)** | **Use a fixed mass of catalyst** at each time (e.g. 1 g) – [1]<br><br>**Place the conical flask in a water bath** to maintain at constant temperature. – [1] *Note that temperature will affect rate of reaction*<br><br>*Also accept any other reasonable answer* | **[2]** |
| **B11(c)** | (i) The **rate of reaction will decrease** [1].<br><br>Coarse manganese(V) oxide power has a **smaller surface area** [1] compared to fine manganese(V) oxide power for particles to react with.<br><br>Hence, particles will have a **lower frequency of collisions** [½], **leading to a lower frequency of effective collisions**. [½]<br><br>(ii) Expected curve should end after 9 min: | **[7]** |




(iii) *Note that moles of hydrogen peroxide will remain constant.*

$$\frac{0.30 \text{ mol}}{1 \text{ dm}^3 + \text{volume of water}} = \frac{0.15 \text{ mol}}{1 \text{ dm}^3}$$ method [1]

Hence, volume of water required = **<u>1.00 dm$^3$</u>** = **<u>1000 cm$^3$</u>** [1]

*Max mark [1] if students show understanding that moles of hydrogen peroxide will remain constant.*