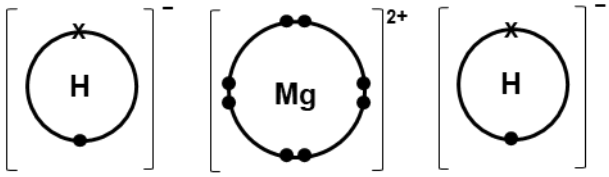
SEC 4 EXPRESS – CHEMISTRY 6092 PRELIM EXAM 2024 - ANSWERS

Paper 1 – MCQ

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

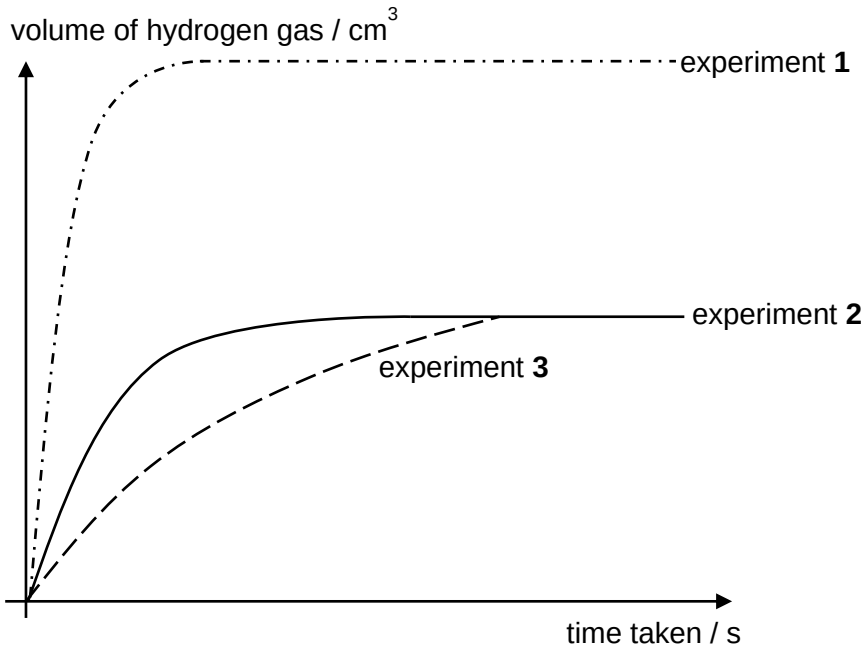
Paper 2 – Section A – Structured Questions

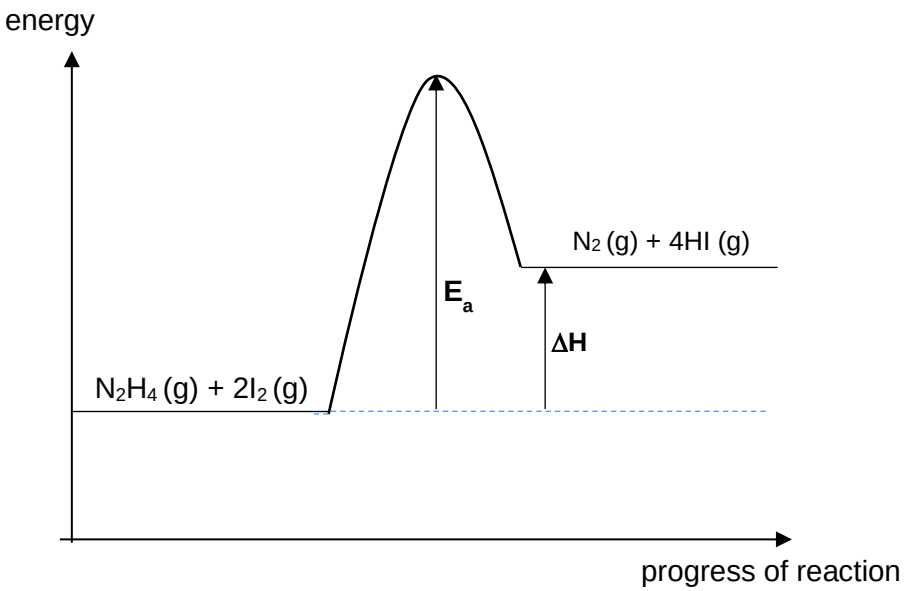
No	Suggested Answers	Marks
1(a)	**silicon dioxide**	**[1]**
1(b)	**calcium oxide / copper(II) oxide**	**[1]**
1(c)	**zinc oxide**	**[1]**
	(i)	
2(a)	**(ii) B**: **iron(II) hydroxide** / **$Fe(OH)_2$** [1] **(iii) C**: **iron(III) hydroxide** / **$Fe(OH)_3$** [1] **(iv) D**: **ammonia gas** / **NH_3** [1] **(v) E**: **silver chloride** / **$AgCl$** [1]	**[4]**
2(b)	**iron(II) chloride** / **$FeCl_3$** [1] **ammonium chloride** / **NH_4Cl** [1] iron(II) nitrate / ammonium nitrate also accepted *e.c.f. allowed; follow part **(a)** answer*	**[2]**
3(a)	**(i) covalent bond** [1] There is **sharing of** valence **electrons** between atoms. [1] wrong choice of terms -0.5 **(ii)** There are **only six valence electrons** surrounding aluminium atom. or Aluminium has **not achieved stable noble gas configuration /valence shell not fully filled**. or aluminium usually loses electrons but shares electrons with hydrogen instead [1]	**[3]**

	NOTE: students should use proper terms e.g. loses electrons instead of giving away electrons / gains electrons instead of taking in electrons.	
3(b)	**(i)**  legend ● : electron of magnesium atom X : electron of hydrogen atom correct magnesium ion – [1]: 0.5 for charge, 0.5 for electrons correct hydride ion x 2 – [1]: 0.5 for charge, 0.5 for electrons −[0.5] for missing legend students should note that magnesium ion should be drawn between hydride ions since there are two hydride ions. **(ii)** Magnesium hydride has a **giant ionic structure^** while aluminium hydride has a **simple covalent structure^**. A **large amount of energy# is needed to overcome the strong electrostatic forces of attraction between oppositely charged ions***, while **only a small amount of energy# is needed to overcome the weak intermolecular forces of attraction between aluminium hydride molecules***. Hence, the melting point of magnesium hydride is so much higher than the melting point of aluminium hydride. Compare type of structures^ – [1] Compare amount of energy# – [1] Compare bonds/forces* – [1] **penalised if wrong choice of words e.g. atoms / ions / molecules for the wrong examples.** **misconception:** **covalent bonds are weak / weaker than ionic bonds** **intermolecular forces between aluminium and hydrogen atoms**	**[5]**
4(a)	**Sulfur dioxide** [0.5] is released into the atmosphere, it will be oxidised by the atmospheric oxygen and **dissolved into rainwater to form acid rain** [0.5]. Acid rain will **corrode limestone buildings and metal infrastructures / destroy crops and vegetation / kill lakes** [1]. *(mentions at least 2 effects)* students confused between silicon dioxide and sulfur dioxide they tend to ignore environmental issue and gave health issues instead.	**[2]**
4(b)	**(i)** aqueous copper(II) sulfate / chloride / nitrate [1] copper(II) hydroxide is rejected since it is insoluble in water	**[5]**

	rejected if (II) was not stated **(ii)** copper plate: $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$ blister copper: $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ many students gave the opposite reactions *Minus half for this question if state symbols missing.* **(iii)** Although the **copper(II) cations are discharged at the cathode**, the **copper anode ionises away to form copper(II) ions** at the same time. [1] - ecf accepted The concentration of copper(II) ions remains the same. [1] quite a number of students did not compare the processes at BOTH electrodes, but only mentioned one only. They should specify the electrodes where the reactions occur. They also did not mention the concentration of copper(II) ions in the electrolyte. OR The **rate of discharge of copper(II) ions at the cathode** [1] is **equals** to the **rate of oxidation of copper atoms at the anode** [1].	

4(c)	Mass of copper in blister copper = 0.96 x 2.00 tonnes = **1.92 tonnes** [0.5] M_r of chalcopyrite = 64 + 56 + 2(32) = **184** [0.5] Since $CuFeS_2 \equiv Cu$, mass of chalcopyrite used = $\frac{184}{64}$ × 1.92 tonnes = **5.52 tonnes** [1] OR Mass of copper in blister copper = 0.96 x 2.00 tonnes = **1.92 tonnes** [0.5] M_r of chalcopyrite = 64 + 56 + 2(32) = **184** [0.5] no. of moles of copper = $\frac{1920000}{64}$ = **30000 moles** [0.5] no. of moles of chalcopyrite = no. of moles of copper = 30000 moles mass of chalcopyrite used = 30000 × 184 = 5520000 g = **5.52 tonnes** [0.5] *e.c.f. allowed* majority of students did not consider the purity of the copper to be 96%. otherwise, most of them could complete the steps mark was awarded for the Mr (0.5) they should also note that the calculation of mass in mole calculations should be in grams, not tonnes/kg.	**[2]**
4(d)	**(i)** Zinc atoms have a **different atomic size** compared to the copper atoms. [0.5] This **disrupts the orderly arrangement** of atoms in copper. [0.5] The **layers of atoms** [0.5] of different sizes **cannot slide over one another easily**, [0.5] making the bronze harder and stronger. generally well done except for some students who failed to mention the layers / unable to use the correct terms e.g. ions/particles/molecules **(ii)** Presence of **free moving / mobile electrons** to act as charged carriers. [1] generally well done	**[3]**
5(a)	**(i)** There are **two times more H^+ ions in experiment 1 than experiment 2 in a given volume** / **more reactant particles in a given volume**. [1] penalised (0.5) for inability to mention per unit volume The particles in experiment **1** will collide more frequently than in experiment **2**. This **increases the frequency of effective collisions** in experiment **1** than in experiment **2**. [1] **penalised for the use of chance/probability instead of frequency/per unit time/ rate of effective collisions** **(ii)** **Granulated zinc** in experiment **3** is bigger in size than powdered zinc in experiment **2**. There is **less (total) surface area (to volume ratio) of contact between reactant particles / less surface area exposed for reactant particles to collide** in experiment **3** than in experiment **2**. [1] The particles in experiment **3** will collide less frequently than in experiment **2**. This **decreases the frequency of effective collisions**. [1] students are reminded to explain according to the question rather than explain the opposite and expect marker to imply	**[4]**

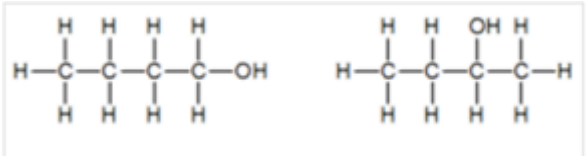
5(b)	**(i)** $H_2SO_4 + Zn \rightarrow ZnSO_4 + H_2$ [1] Number of moles of H_2SO_4 = 25/1000 x 0.5 = 0.0125 mol Molar ratio of H_2SO_4 : H_2 = 1 : 1 Therefore, number of moles of H_2 = **<u>0.0125 mol</u>** [1] Maximum volume of hydrogen gas = 0.0125 x 24 = **<u>0.300 dm^3</u>** OR **<u>300 cm^3</u>** [1] students are reminded not to include state symbols unless specified in the question. penalised (0.5) if state symbols are written BELOW the formulae. penalised (0.5 per paper) if no 3 sf for final answer	**[5]**
	(ii)  experiment **1** – steeper gradient, twice the volume of gas – [1] experiment **3** – gentler gradient, same volume of gas – [1] generally well done except the volume of gas for expt 1	
5(c)	**<u>Catalyst increases the rate of reaction</u>**, [0.5] hence **<u>the time taken to collect hydrogen gas will be lower than 20 s</u>**. [0.5] generally not well done as students are unable to quote 20s / mentioned time taken 'faster' which is conceptually incorrect	**[1]**
6(a)	**<u>fractional distillation of liquefied air</u>** [1] reject if no mention of fractional distillation / liquid / liquefied	**[1]**
6(b)	**(i)** **<u>Yield of ammonia decreases</u>** at higher temperature/ **thermal decomposition of ammonia**. [1] **(ii)** **<u>Rate of formation of ammonia will decrease</u>** / **<u>takes a longer time to obtain the ammonia</u>** / **<u>reaction will slow down</u>**.[1] generally well done	**[2]**

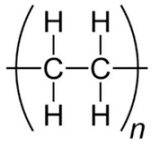
6(c)	Ammonium ions from the **ammonium fertilisers will react with the (excess) calcium oxide** to produce ammonia. [1] The nitrogen in the form of **ammonia gas is lost to the surroundings** instead of taken in by the plants. [1] poorly attempted. It was evident that students are not familiar with this concept and the implications in the agricultural context misconceptions: ammonium salt is alkaline reaction of ammonium salt and base yields nitrogen gas	**[2]**
6(d)	**(i)** Energy absorbed to break bonds = 170 + 4(391) + 2(151) = 2036 kJ [0.5] Energy released during bond making = 945 + 4(161) = 1589 kJ [0.5] Enthalpy change of reaction = +2036 – 1589 = **+447 kJ** [1] penalised (0.5) for no sign students should show their calculations clearly by writing phrases beside what they are calculating	**[5]**
	(ii)  correct profile of diagram – [1] label reactants and products – [1] label enthalpy change and activation energy correctly – [1] ecf allowed generally well done	
7(a)	The **ratio of each element to chlorine decreases [0.5] from 1:1 to 1:4 from lithium to carbon**, [0.5] **and increases [0.5] from 1:4 to 1:1 from carbon to fluorine**. [0.5] Qn was poorly done as many students did not know what a decreasing or increasing ratio is. *Note: Students should look out for general trends (i.e. increase or decrease) when describing "pattern" instead of simply listing all the ratios.*	**[2]**
7(b)	**(i) beryllium chloride / $BeCl_2$** **(ii) $NCl_3(g) + 3H_2O(l) \rightarrow NH_3(aq) + 3HClO\ (aq)$**	**[3]**

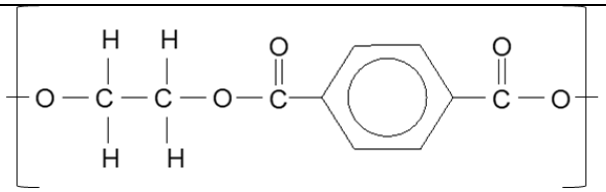
	balanced chemical equation – [1] *correct state symbols – [1]*	
7(c)	The reaction between boron trichloride and water is **not a redox reaction**. *No mark is awarded if there is no explanation / explanation is incorrect.* This is because the **oxidation state of B remains the same at +3 in BCl_3 and H_3BO_3**; [1] and the **oxidation stae of C*l* remains the same at -1 in BCl_3 and HC*l***. [1] *Must make reference to oxidation states.*	**[2]**
7(d)	The **data does not support the ideas of students 1 and 2**. [1] *No mark is awarded if there is no explanation / explanation is incorrect.* Both **$BeCl_2$ being a metal chloride** [0.5] and **BCl_3 being a non-metal chloride can hydrolyse too**. [0.5] *Accept: comparison between $BeCl_2$ and LiCl* Not all chlorides of elements across Period 2 with covalent bonding hydrolyses. **CCl_4, being a chloride with covalent bonding, is immiscible with water**. [1]	**[3]**
7(e)	use a **separating funnel**	**[1]**
8(a)	**(i)** The **annual emission of carbon monoxide, oxides of nitrogen and sulfur dioxide generally decreases** over the last 15 years. [1] **(ii)** **Carbon monoxide** is the main air pollutant which poses a threat to the US. [1] This is because carbon monoxide **will reduce the transport of oxygen around the body and can cause headaches / giddiness / eventually lead to death**. [1] Qn was very poorly done. Many students had the misconception that CO is an acidic oxide, like CO_2. Also, CO does not cause "*breathing difficulties*" and "*suffocation*", unlike pollutants like sulfur dioxide. *Note: students should give at least 2 effects for similar questions!*	**[3]**
8(b)	**No / Disagree.** *No mark is awarded if there is no explanation / explanation is incorrect.* The **emission from vehicles forms the main source of air pollutants for carbon monoxide (78.4%) and oxides of nitrogen (59.1%)**. [1] *Students should identify that the main air pollutants from emission from vehicles. [0.5]* *% values must be included. [0.5]* However, the **main source of sulfur dioxide comes from power station** [0.5] **with a high percentage of 77.2%** [0.5] **instead of 1.9% from the emission from vehicles**.	**[2]**

	Students should be able to make comparison using data and elaborate why emission from vehicles is not the main source for all air pollutants.	
8(c)	**(i)** **$2CO + 2NO \rightarrow 2CO_2 + N_2$** **(ii)** As the amount of air is increased, the **percentage of CO removed from the converter increases**, while the **percentage of NO removed decreases**. [1] An increased in the amount of air provided a **larger amount of atmospheric oxygen to react/oxidise CO** to form CO_2. [1] However, this **reduces the amount of NO that is required to oxidise CO / less amount of CO to react with NO**. [1] *Candidates need to make reference to the data given.* **(iii)** While the **percentage of carbon monoxide removed increases, the percentage of nitrogen monoxide removed remains constantly high**. This suggests that there must be other substances reacting with nitrogen monoxide to remove it. Qn was very poorly done. Students should focus on initial part of graph. The second part of graph was already explained in part (ii).	**[5]**

Paper 2 – Section B

No	Suggested Answers	Marks
9(a)	Butene contains a **carbon-carbon double bond**.	**[1]**
9(b)	**Long-chain hydrocarbon molecules** are **broken down** [0.5] into **shorter-chain/smaller (hydrocarbon) molecules** [0.5] in the presence of a catalyst. Several students had the misconception that cracking is the same as fractional distillation.	**[1]**
9(c)	**(i)** **300°C** (*1 mark point*) **60 atm** (*1 mark point*) **phosphoric(V) acid** (as a catalyst) (*1 mark point*) 3 mark points – [2] 1 or 2 mark points – [1] **(ii)**  [1] for each isomer	**[4]**
9(d)	**(i)** M_r of 1,3,5-hexatriene = 6(12) + 8(1) = 80 M_r of hexane = 6(12) + 14(1) = 86 Mass of hexane expected from 20.0 kg of 1,3,5-hexatriene $= \frac{86}{80} \times 20.0 =$ **21.5 kg** [1]	**[4]**

	Since the hydrogenated product weighs only 21.0 kg, this shows that **not all the carbon-carbon double bonds have been hydrogenated**. Hence the product is still unsaturated. [1] **(ii)** Pipette 25.0 cm^3 of each organic compound into a conical flask and titrate them with aqueous bromine from a burette [1]. The one requiring a **larger volume of aqueous bromine** to produce a permanent **orange/brown colour** on addition of one drop of aqueous bromine is 1,3,5-hexatriene [1]. *(any other reactions which shows product is unsaturated).* *[1] awarded if student is able to describe using red-brown aqueous bromine to test for unsaturation.* *Tricky question which was poorly attempted.* *Note that both products are still UNsaturated, however the number of unsaturated bonds are not the same after the reaction.*	
10(a)	**(i)**  [1] **(ii)** relative molecular mass of ethene monomer = 2(12)+4(1) = **28** [1] Hence, the number of monomers in polymer = 40,000 / 28 = 1428.57 ≈ **1428 / 1429 / 1430** monomer [1] *e.c.f. allowed* Since each monomer contains 2 carbon atoms, hence total number of carbon atoms presence in polymer = 2 x 1428.57 = 2857.14 ≈ **2857 / 2858 / 2860** carbon atoms [1] *e.c.f. allowed* **(iii)** -melt small pieces of plastic waste into pellets which can then be made into new products -cracking of plastics to form shorter chain alkanes and alkenes to use as fuels / other useful chemicals -deploymerisation through acid hydrolysis to form monomers *any 2 of the above 3 points; students must describe* Qn was poorly attempted. Many students were vague or ambiguous in their responses.	**[6]**
10(b)	**(i)** There is **no ester or amide linkage** [0.5] **between repeating units** [0.5] in the structure. **(ii)** Add **aqueous bromine** [1] to both compounds. The monomer will **decolourise reddish-brown bromine solution** [0.5] immediately, whereas **no reaction / visible change** [0.5] is observed in butane.	**[3]**
10(c)		**[1]**

	 Qn was poorly attempted. Repeating unit should always show the linkage in the middle. Some students were penalised as the functional groups at the end not reflected correctly after bonding.	