EXAM ANSWERS

Year:	**2024**
Exam:	**Prelim**
Level/Stream:	**4E**
Subject:	Chemistry **6092**

P2

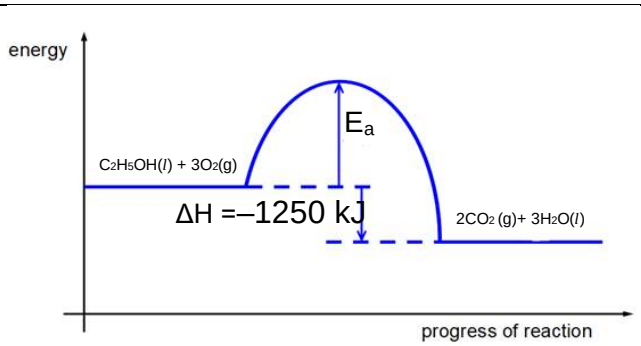
Qn	Answer	Marks	Comments
1 a i ii iii iv v	 chlorine **and** oxygen iron(II) chloride argon carbon **and** chlorine iron **and** iron(II) chloride	5	**1m each**
A1 b	Addition reaction with hydrogen ACCEPT: Hydrogenation / Addition with Hydrogen / addition of H_2 Esterification Neutralisation ACCEPT: neutralization REJECT: acid-alkali reaction	3	1m each

Qn	Answer	Marks	Comments
2a	The **mass** of the mothballs decrease / becomes smaller over time. REJECTED: Mothballs become smaller / reduce in size / shrink. This indicates that the mothball is gradually disappearing, which can be explained by sublimation, where the mothball turns from a solid into a gas without going though the liquid state. ACCEPT: sublimation / solid sublimes to form gas / solid particles gain sufficient energy to overcome forces of attraction and become gas/gaseous particles. REJECT: decomposition	2	1 - trend 1 - reason

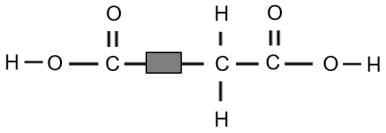
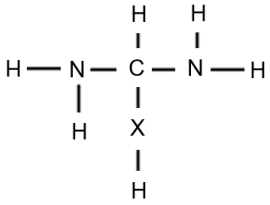
2b	Diffusion is the movement of gas molecules from a region of higher concentration near the mothballs to a region of lower concentration throughout the cupboard. As the molecules are spread out and mixed with the air molecules, the pungent smell can be observed. / Gas molecules (of mothball) collide/ mix with molecules in the air and spread across the room/space. REJECTED: travel / move	1 1	1m – diffusion definition on solute movement 1m- mixing with air molecules

Qn	Answer	Marks	Comments
3a i	Fractional distillation REJECTED: distillation, fractionating distillation	1	
3a ii	In the furnace, the crude oil is heated into a vapour / heated and vapourise before it enters the fractionating column. The vapour contains a mixture of hydrocarbons with different boiling points. As the vapour rises up the column, the fractions with lower boiling points rise further up the column and condense at a lower temperature while the fractions with higher boiling points condense at a higher temperatures and collect at the lower part of the column. / As the vapour rises up the column, the fractions with higher boiling points condense and are collected at lower down the column while the fractions with lower boiling points rise further up the column to be collected. Jet fuel is collected as one of the fractions.	1 1	
3b	Used cooking oil contains impurities such as water. As the used cooking oil is placed in the separating funnel, the mixture separates into different layers based on density differences. When allowed to settle, the liquid that is denser can be tapped off from the bottom, the remaining layer will be the processed oil. (OWTTE)	1 1	Qn stated water as impurities; water is denser than cooking oil and settles at the bottom layer.

3c	Carbon dioxide is released/produced/given out during the burning/combustion of bioethanol, while bioethanol produced by the sugarcane plants which absorb/take in carbon dioxide during photosynthesis. This does not increase the net amount of CO_2 in the surroundings. **OR** The amount of carbon dioxide released/produced/ given out from the burning/combustion of bioethanol **is offset** by the amount of carbon dioxide absorb/take in carbon dioxide during photosynthesis of the sugar cane plant. However, other processes such clearing of land for sugarcane crops and burning of fossil fuels during farming or transporting of sugarcane would releases even more carbon dioxide, making the use of bioethanol less sustainable.	1 1 **OR** 2 1	Key processes AND CO_2 produced/absorbed. Carbon neutral Other processes (related to making of bioethanol) that release CO_2
3c	Overall enthalpy change = Total energy absorbed during bond-breaking in reactants – Total energy released during bond-forming in products = [350 + 5(410) + 358 + 460 + 3(496)] – [2 x 2(799) + 3 x 2(460)] = 4706 – 5956 = –1250 kJ CAP 1 mark for "1250 kJ"	2	1m – for suitable working, correct number of bonds 1m – for correct answer
3d		3	1m – correct shape (exothermic) with reactants and products labelled with (state symbols)

	 CAP 1 mark for E_a if wrong shape of profile diagram is drawn. ECF wrong ΔH calculated from (c) if ΔH is negative. REJECT: positive ΔH, double-head arrows, 'floating' arrows IGNORE: miss enthalpy value (i.e. - 1250 kJ), eqn which is not balance		1m – E_a labelled 1m – ΔH with values labelled (value ECF)

Qn	Answer	Marks	Comments
4 a	Assume 100g of compound. IGNORE if missing. C: Mass 40.8; A_r 12; Mole $\frac{40.8}{12} = 3.4$; Divide by smallest no 3.4/0.6786 = 5.0106; Simplest ratio 5 H: Mass 6.1; A_r 1; Mole $\frac{6.1}{1} = 6.1$; Divide by smallest no 6.1/0.6786 = 8.9895; Simplest ratio 9 N: Mass 9.5; A_r 14; Mole $\frac{9.5}{14} = 0.6786$; Divide by smallest no 0.6786/0.6786 =1; Simplest ratio 1 O: Mass 43.6; A_r 16; Mole $\frac{43.6}{16} = 2.725$; Divide by smallest no 2.725/0.6786 = 4.0158; Simplest ratio 4 $C_5H_9NO_4$ ACCEPTED any order of elements.	1 1	Working for calculation of moles correct empirical formula
4b	– / -1 / 1- / minus 1 / negative 1	1	

4c i	Amide linkage	1	
4 c ii	 Monomer 1 IGNORE unshaded box (marker will annotate for student, teacher please remind)  Monomer 2	2	
4 c iii	Sulfur REJECT: oxygen (question stated five different elements)	1	
4 d	C=C bond / carbon-carbon double bond REJECTED: double C=C bond, double carbon bond.	1	

Qn	Answer	Marks	Comments
5 a i	Reducing agent, hydrogen has removed oxygen atoms from PbO to form Pb. ACCEPTED: Hydrogen takes/took away oxygen; PbO lost oxygen to hydrogen to form Pb; Hydrogen caused PbO to lose oxygen and formed Pb and itself is oxidized. REJECTED: Lead/Pb lost its oxygen from PbO to Pb	1	
5 a ii	No, aluminium is more reactive than hydrogen / aluminium is a reactive metal that is placed above hydrogen in the reactivity series / hydrogen is less reactive than aluminium and cannot displace aluminium form its ore. It can only be extracted by electrolysis of its molten oxide. REJECTED: Aluminium is more reactive than iron (note that this does not answer to the context).	1	

5 a iii	After the heating has stopped, the extracted lead metal is still very hot. With the constant flow of hydrogen gas, it prevent the oxygen from the surrounding air form reacting with hot lead metal to form lead(II) oxide. Propose CAP 1 mark for To ensure complete reduction (of lead(II) oxide) / to ensure all lead(II) oxide fully reduced to lead. REJECTED: to prevent hydrogen from reacting with oxygen in the air; to avoid hydrogen from combusting with oxygen/air.	1 1	
5 b i	H_3PO_3 is oxidised because the oxidation state of phosphorus increases from +3 in H_3PO_3 to +5 in H_3PO_4 . H_3PO_3 is also reduced because the oxidation state of phosphorus decreases from +3 in H_3PO_3 −3 in PH_3 . CAP 1 mark for correct oxidation states of phosphorus in all compounds but did not specify oxidized / reduced with respect to increase / decrease of oxidation states.	1 1	
5b ii	Comproposition reaction is a reaction in which the same element in two different reactants is both oxidised and reduced, forming one/a (single) product containing the element. Or OWTTE e.g. Comproposition reaction involves two different reactant containing the same element undergoing redox reaction / reduction and oxidation to form a/one product containing that element.	1	

Qn	Answer	Marks	Comments
6 a i	By providing an alternative pathway of lower activation energy to speed up / increase / fasten the rate of reaction.	1	
6 a ii	Comparing experiments 2, 3 and 4. When copper catalyst is used, reaction time decreased by 7 seconds, hence faster rate of reaction. Copper is an	1	use data to compare time

	effective catalyst. But silver catalyst reduced time by 1s, reduction of time is not significant/not acting as a catalyst/not an effective catalyst. CAP 1M when effectiveness of Silver as a catalyst is not mentioned	1	conclusion of effective and not effective
6 b i	**Concentration** ● In experiment 1 and 2, doubling the concentration of aqueous potassium iodide solution, increases the number of reacting particles per unit volume, hence increasing the total number of collisions between particles. **Temperature** ● In experiment 2 and 5, increasing the temperature increases the kinetic energy of the reacting particles and hence, more particles possess energy equal to or greater than the activation energy for reaction. ● In both cases, the frequency of effective collisions between reacting particles increases and hence, rate of reaction (rate of formation of iodine) increases. ● Therefore, the time taken for the blue black colour to appear decreases. CAP 2 marks if data from question, experiment numbers and time/decrease in time are not quoted.	1 1 1 1	Explain effect of ↑ conc on no. of reacting particles Explain effect of ↑ temp on energy of reacting particles Link both to increased frequency of effective collision Relate to time taken to ↓
6 b ii	The iodine produced dissolves in the solution to produce a brown solution. The experiment involves iron(III) solutions, which is brown. The end point cannot be determined as I_2 in solution is also brown hence the reaction between iodine and starch to turn the solution blue black will help determine the end point of the reaction. CAP 1m for students who can link to starch being an **indicator** to signal formation of iodine	1 1	

<table>
<tr><th>Qn</th><th>Answer</th><th>Marks</th><th>Comments</th></tr>
<tr><td>7ai</td><td>Volcano / volcanic <u>eruptions/activities.</u></td><td>1</td><td></td></tr>
<tr><td>7aii</td><td>Sulfur dioxide emissions from vehicles and power stations decreased while emissions from refineries remained constant.

REJ : total emission decreased</td><td>1</td><td></td></tr>
<tr><td>7bi</td><td>SO_2 (g) + $MgCO_3$ (s) → $MgSO_3$ (s) + CO_2 (g)

IGNORE: water (in whichever state)
$SO_2(g) + MgCO_3(s) + \cancel{H_2O(l)} \rightarrow MgSO_3(s) + CO_2(g) + \cancel{H_2O(l)}$
Exception of water on reactant but not products (equation is not balanced)
i.e.
$SO_2(g) + MgCO_3(s) + H_2O(l) \rightarrow MgSO_3(s) + CO_2(g)$</td><td>2</td><td>1m formula
1m state symbol</td></tr>
<tr><td>7b ii</td><td>The beads in the packed bed allows <u>a larger / greater / more / bigger surface area</u> for the reaction/scrubbing to take place. Hence, more SO_2 can be removed.</td><td>1</td><td></td></tr>
<tr><td>7b iii</td><td>The system is <u>too big / bulky / costly</u> to be fitted on cars.

ACCEPT: not portable, not practical to replace magnesium sulfite</td><td>1</td><td>Mentioned in TB</td></tr>
<tr><td>7c</td><td>Mole of $SO_2 = \frac{1\,280\,000}{64} = 20\,000$mol
Mole ratio 1: 1
<table>
<tr><td></td><td>Moles required</td><td>M_r</td><td>Mass/g</td><td>Cost</td></tr>
<tr><td>$CaCO_3$</td><td>20 000 mol</td><td>100</td><td>2 000 000</td><td>$\frac{2\,000\,000}{1000} \times 0.11$ = $220.00</td></tr>
<tr><td>$MgCO_3$</td><td>20 000 mol</td><td>84</td><td>1 680 000</td><td>$\frac{1\,680\,000}{1000} \times 0.14$ = $235.20</td></tr>
</table>
Using calcium carbonate is cheaper.

ACCEPT alternative methods:
Comparison by cost per mole of substance
Comparison by amount of substance (mole) for a fixed cost.

REJECT: method that compares mass (in kg or g) for fixed cost or vice versa.</td><td>1

1

1</td><td>1m – relating mole of SO_2 to mole of carbonate required.

1m evaluating cost for mass of respective carbonates and making conclusion.

1m – Presentation “showing clear calculations”</td></tr>
</table>

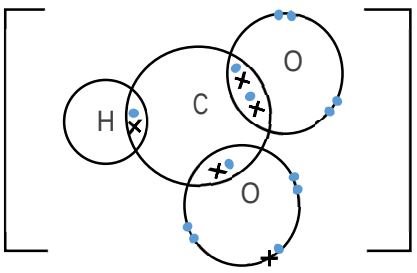
<table>
<tr><th>Qn</th><th>Answer</th><th>Marks</th><th>Comments</th></tr>
<tr><td>8a i</td><td>
<table>
<tr><th rowspan="2">name of substance</th><th rowspan="2">chemical formula</th><th colspan="3">type of covalent bond(s) present</th></tr>
<tr><th>polar</th><th>non-polar</th><th>not applicable</th></tr>
<tr><td>hydrogen chloride</td><td>HCl</td><td>✓</td><td></td><td></td></tr>
<tr><td>sodium fluoride</td><td>NaF</td><td></td><td></td><td>✓</td></tr>
<tr><td>methane</td><td>CH_4</td><td></td><td>✓</td><td></td></tr>
<tr><td>ozone</td><td>O_3</td><td></td><td>✓</td><td></td></tr>
</table>
</td><td>3</td><td>3m – 6 correct
2m – 4 or 5 correct
1m – 2 or 3 correct.</td></tr>
<tr><td>8a ii</td><td>Across period 2, from <u>carbon to fluorine</u> the electronegativity increases from <u>2.55 – 3.98</u>.
Down group 17, from <u>fluorine to bromine</u>, the electronegativity decreases from <u>3.98 – 2.96</u>.

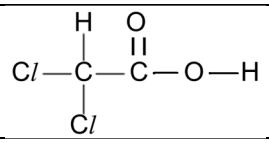
IGNORE: MISSING values in answer i.e. don’t undermine the numbers.

IGNORE: missed out fluorine when describing period 2.</td><td>1

1</td><td></td></tr>
<tr><td>8bi</td><td>pH of acid <u>increases</u> as <u>concentration/amount of hydrogen ions per unit volume decreases</u>

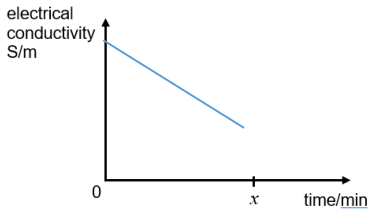
due to the presence of electron-donating group which causes <u>formation/reformation of acid molecules</u> and hence <u>reduced/decreased the (extent) of ionisations/dissociation (of acid)</u>.</td><td>1

1</td><td>Just stating pH increase/decrease → no marks awarded (probability 0.5)</td></tr>
<tr><td>8bii</td><td> 
</td><td>2</td><td>1m – correct conversion of structural formula to electrons (including the negative charge)

1m – duplet/octet (including extra electron on O)</td></tr>
<tr><td>8ci</td><td> 
</td><td>1</td><td></td></tr>
</table>

8cii	*Chloroethanoic acid / bromoethanoic acid / fluoroethanoic acid has a <u>higher</u> dissociation constant (of ... *value from the table*) than ethanoic acid. This shows that the <u>presence of halogen / an electronegative atom</u> in the R group which is electron-withdrawing. *comparison of dissociation constant of any two organic acid	1 1	

Section B

Qn	Answer	Marks	Comments
9a	<u>Concentrated</u> sodium chloride solution ACCEPTED: <u>concentrated</u> aqueous sodium chloride REJECTED: saturated	1	
9b	Cathode : $2H^+(aq) + 2e^- \rightarrow H_2(g)$ Anode: $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$ Max 1m if student mixed up cathode and anode half equation. (No ecf for test for chlorine gas) Allow ECF for anode if candidate answered aqueous/dilute NaCl in **(a),** **i.e.** $4OH^-(aq) \rightarrow O_2(g) + 2H_2O(l) + 4e^-$	1 1	
9c	Insert a lighted splint into the gas. Gas extinguishes lighted splint with a 'pop' sound. **ACCEPT** pop, "pop", 'pop', gas gives "pop" sound with lighted splint. Allow ECF for correct test for wrong gas identified in **(b)**	1	
9d i		1	<u>Decreasing</u> line or curve Does not touch 0 (imply that ions are still present)

9d ii	As electrolysis proceeds, ions are discharged at the electrodes, this decreases the number of ions per unit volume/concentration of ions. Hence, electrical conductivity decreases.	1 1	discharge of ions idea of concentration
9 e i	Platinum, like graphite, is an inert electrode.	1	
9 e ii	The silver electrode/anode becomes smaller/reduced in size/ shrink over time. Reactive silver electrode loses electrons/is oxidise/undergoes oxidation and forms silver ions in the electrolyte. OR White precipitate is formed in the electrolyte over time. The silver electrode/anode loses electrons/is oxidise/undergoes oxidation to form silver ions which react/combined with chloride ions in the electrolyte to produce insoluble silver chloride. REJ: silver is lower than hydrogen in the reactivity series. The focus of this question is on silver being a reactive electrode. Silver is not an inert electrode (do not use reverse argument), just say that silver is a reactive electrode.	1 1 **OR** 1 1	Observation Explanation

Qn	Answer	Marks	Comments
10 a	In graphite, each carbon atom is bonded to only three other carbon atoms, thus each carbon atom has a valence electron that is not bonded and delocalised. These electrons can act as mobile charge carrier to conduct electricity, hence the circuit is closed. **CAP 1m for** - presence of delocalised / free-moving / mobile electrons if student did not or poorly elaborate on the structure of graphite.	1 1	Explain 1 electron per carbon atom Mobile charge carrier
10 b	Copper Oxygen	1 1	
10 c	Insert a glowing splint into the gas. The gas relights a glowing splint.	1	

	Allow ECF for correct test for wrong gas identified in **(b)**		
10 d i	When two different metals are put together, the <u>difference in their reactivity</u> <u>causes the movement of electrons</u>, which enables the bulb to be lighted up. In experiment I, <u>graphite is inert</u> and does not take part in any reaction. In experiment II, both electrodes are <u>made of the same metal</u>/ has <u>no difference in the reactivity</u>. There is no movement of electrons, hence bulb did not light up. **OR** In experiment 1, graphite is an <u>inert</u> electrode / is <u>not a metal</u>. In experiment 2, the two metal electrodes are the same and hence there is <u>no potential difference / no difference in the reactivity.</u> REJECT: There is no difference in reactivity between graphite and W. Should not use reverse argument i.e. The two electrodes are not different.	1 1 **OR** 1 1	1m Understanding simple cell, chemical reactions, electron movement caused by different reactivities. 1m Inert, and same metal
10 d ii	X, Y, Z, W	1	
10 d iii	Lead reacts with dilute sulfuric acid to form a <u>layer of insoluble lead(II) sulfate</u> around the surface of the lead electrode. As the electrode is <u>no longer a conductor of electricity</u>, the (discharging of ions is unable to take place), the <u>circuit breaks</u> and the bulb does not light up anymore. REJECT: prevent further reaction → Need to elaborate on what is prevented.	1 1	