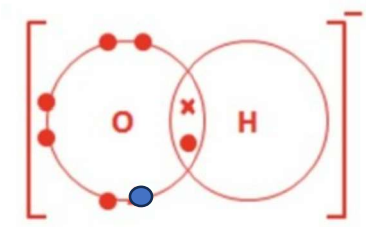
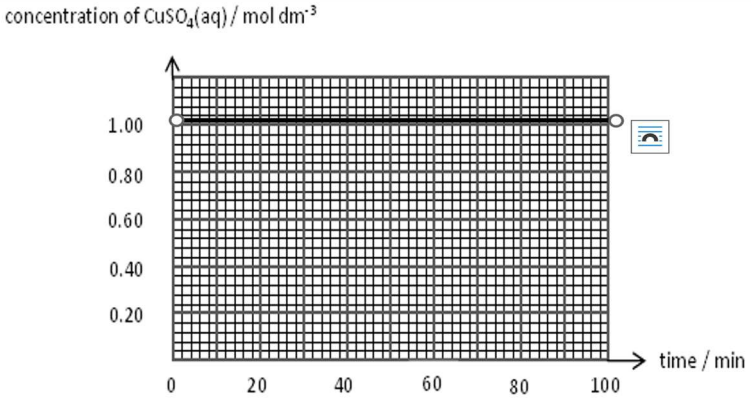
2024 ZHSS Pure Chem (6092) Preliminary Examination

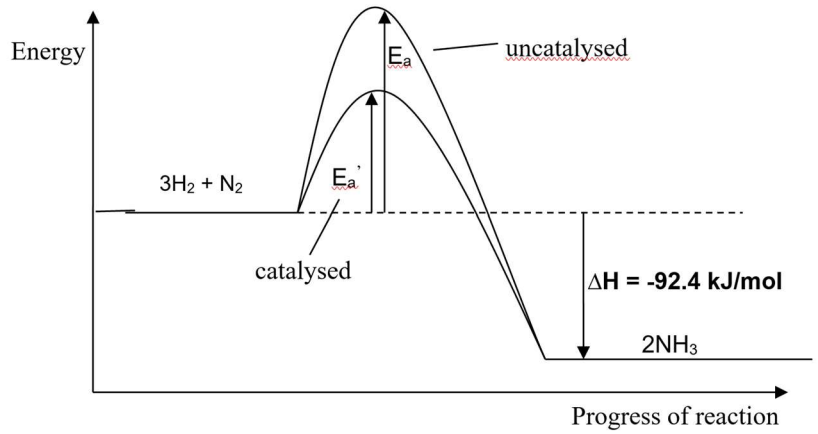
<table>
<tr><td colspan="3">Section A (70 m)</td><td></td></tr>
<tr><td>1</td><td>(a)</td><td>
<table>
<tr><td></td><td></td><td>Put a tick (√) if a redox reaction has occurred.</td></tr>
<tr><td>(i)</td><td>a copper strip added to zinc nitrate solution</td><td></td></tr>
<tr><td>(ii)</td><td>aqueous chlorine added to potassium iodide solution</td><td>√</td></tr>
<tr><td>(iii)</td><td>hydrogen gas passed over heated copper(II) oxide</td><td>√</td></tr>
<tr><td>(iv)</td><td>Dilute sulfuric acid reacts with lithium hydroxide</td><td></td></tr>
</table>
(1m each)</td><td>2</td></tr>
<tr><td></td><td>(b)</td><td>Difference: Reaction rate is slower when used with aqueous bromine.
Explain: Chlorine is more reactive than bromine/ gains electrons more readily (and displaces iodine from iodide solution faster);</td><td>1
1</td></tr>
<tr><td></td><td>(c)</td><td>$CuO + H_2 \rightarrow Cu + H_2O$</td><td>1</td></tr>
<tr><td></td><td></td><td></td><td>[5]</td></tr>
<tr><td>2</td><td>(a)(i)</td><td>• Silicate has an orderly arrangement, while soda-lime glass does not have an orderly arrangement.
• Each oxygen atom is covalently bonded to 2 Si atoms in silicate, but not all oxygen atoms are covalently bonded to 2 Si atoms in soda-lime glass;
• Silicate contains only covalent bonds, but soda-lime glass contains covalent and ionic bonds;
Any two points</td><td>2</td></tr>
<tr><td></td><td>(ii)</td><td>Conducts electricity only in molten state.
There are more free moving/mobile ions that act as charge carriers</td><td>1
1</td></tr>
<tr><td></td><td>(b)(i)</td><td>Potassium hydroxide has a giant lattice structure;
A large amount of energy is needed to overcomes the strong forces of attraction between the oppositely charged ions;

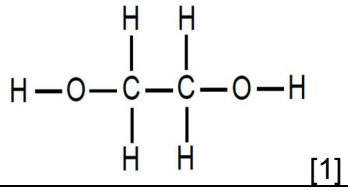
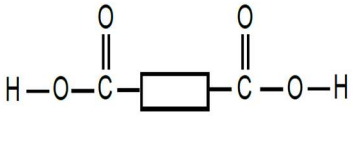
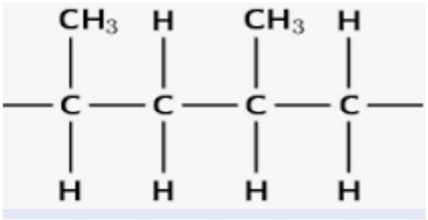
Chlorine has a simple molecular/ covalent structure
where a small amount of energy is needed to overcome weak intermolecular forces;
structure 1m, bonding & energy 2 m</td><td>1
1

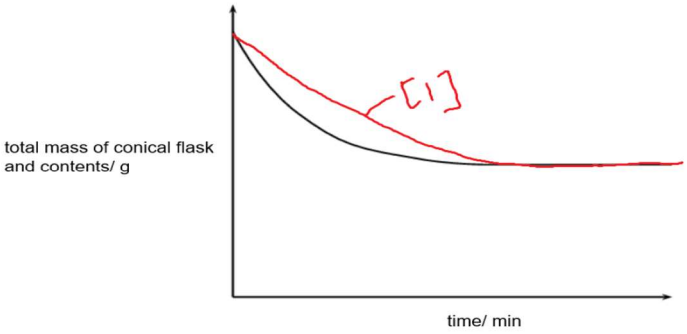
1</td></tr>
<tr><td></td><td>(ii)</td><td>hydroxide ion, OH^-
O 2.6, H 1
 
</td><td>2</td></tr>
<tr><td></td><td></td><td></td><td>9m</td></tr>
</table>

3	**(a)**	The greater the solubility of a solute in the mobile solvent, the faster the solute moves up the paper, the higher the spot is on the paper.	1
	(b)(i)	2 spots (no mark awarded) Pigments **X** and **Y** have **the same R_f value of 0.6** and thus travelled the distance up the chromatogram **appearing as one spot**. Pigment **Z** has **smaller Rf value of 0.1** and thus travelled a shorter distance up the chromatogram, appearing **as another different spot**.	1 1
	(ii)	Pigment **Z** and **Y** would not have been separated from the mixture as they are insoluble in pure water and pure ethanol respectively.	1 1
			5m

4	**(a)**	Concentration of $CuSO_4$ decreases from 1.00 mol/dm^3 until there is no more Cu^{2+} ions in solution as Cu^{2+} ions is reduced to form Cu at the cathode. $Cu^{2+}(aq) + 2e \rightarrow Cu(s)$	1 1
	(b)	**Use aqueous sodium hydroxide**, **blue ppt insoluble** in excess if there is copper(II) ions present **OR** **Use aqueous ammonia solution**, **blue ppt** soluble in excess to form a dark blue solution.	1
	(c)	Amount of Cu deposited = 200/1000 X 1.00 = 0.200 mol (1) Mass of Cu = 0.200 X 64 =12.8 g [1] Increase in mass of the iron object = **12.8 g**	2
	(d)(i)		1

	(ii)	solution	name of products of electrolysis		ionic equation for reaction at each electrode	
		silver nitrate solution	at anode	**silver ions**	**Ag(s) → Ag+(aq) + e**	1
			at cathode	**Silver coated on iron object**	Ag^+ (aq)+ e → Ag(s)	1
	(iii)	$Ag^+ + e \rightarrow Ag$ The **same quantity of electricity** passes through the circuit as the previous set-up and since Ag^+ requires **half the no off mole of electrons** to be reduced as compared to Cu^{2+}. No of mole of Ag^+ =0.200 X 2 = **0.400 mol.** Increase in mass of in cell B = 0.400 X108 **=43.2 g**				1 1
						[10]
5	**(a)**	Percentage yield **decreases** with increase in temperature (1) reaction is exothermic / increasing temperature favours reaction which absorbs heat (1)				2
	(b)	 Any mistakes -1m / wrong curve- no mark				3
	(c)	Comparing the equation in steps 1 and 2 and cancelling the same components on the left and right of the equations. $NH_3 + NaOCl \rightarrow NH_2Cl + NaOH$ $NH_3 + NH_2Cl + NaOH \rightarrow N_2H_4 + NaCl + H_2O$ (+ **$2NH_3 + NaOCl \rightarrow N_2H_4 + NaCl + H_2O$**				1 1

	(d)	$2NH_3 + NaOCl \rightarrow N_2H_4 + NaCl$ (***allow ecf if the equation is wrong***) No of moles of N_2H_4 = 75/ Mr N_2H_4 = 75/2(14) + 4(1) =2.34 mol Mole ratio: N_2H_4 : NH_3 1 : 2 2.34 : 2.34 x 2 = 4.68 mol Mass of ammonia = 4.68 X Mr NH3 = 4.68 x 17 = 79.56 g % purity of ammonia = 79.56/ 100g x 100% =**79.6% (3sf)**	1 1
	(e)(i)	$NH_3 + 3HOCl \rightarrow NCl_3 + 3H_2O$	1
	(ii)	N is oxidized as the oxidation state of N increases from-3 in NH_3 to +3 in NCl_3. Cl is reduced as the oxidation state of Cl decreases from +1 in Cl to -1 in NCl_3 Since oxidation and reduction occur, it is a redox reaction.	1
			[11]
6	**(a)(i)**	 [1]  [1]	2
	(ii)	Catalyst/enzyme	1
	(b)(i)	name - butanal formula - C_3H_7CHO	1 1
	(ii)	$C_nH_{2n+1}CHO$ / $C_{n-1}H2_{n-1}CHO$	1
	(iii)	Length of carbon chain/number of carbon atoms, increase in the intermolecular forces of attraction between the molecules ACCEPT percentage by mass of carbon	1 1
	(d)(i)	2 repeat units of poly(propene) 	1

	(ii)	Waxworms can remove non-biodegradable plastic from the environment, reducing pollution.	1
			10
7	**(a)(i)**		1
	(ii)	Chlorine gas is soluble in water so the mass loss is less than expected	1
	(iii)	Change: use a gas syringe to measure the volume of chlorine gas at regular intervals. Explanation: Chlorine gas is collected once is produced. Less gas will be soluble in the water.	1 1
	(b)	Conclusion 1: increase in the surface area of contact between particles [1] Conclusion 2: MnO_2 is a catalyst + no change in the amount/ mole of limiting reactant / no change in yield. [1]	2
	(c)	Catalyst provides **an alternative pathway with a lower activation energy.** Particles possesses **energy greater or equal to than the activation energy** thus increases the frequency of effective collision.	1 1
			8m
		Data-based question	
8	**a(i)**	**NOx, rated C2**	1
	(ii)	With the worst performing pollutant at C2, there is a **surcharge of $25000**.	1
	(b)	Carbon dioxide is a **greenhouse gas results in global warming** which causes **an increase in the average temperature of the Earth's surface** Any valid description of effect of increased global temperature. i.e heat waves/droughts, melting of polar caps etc	1 1
	c(i)	Nitrogen oxides which has an increase increased by 2.5 g. (carbon monoxide decreases by 1g; hydrocarbon remains the same) For the speed of the car to increases, more fuel are combusted and thus **the engine gets hotter / increase in temperature/ high temperature** in car engine causes more nitrogen and oxygen in the air to react to form nitrogen oxides	1 1
	(ii)	As the speed increase from 50 km/h to 80km/h, the mass of carbon monoxide decreases as the **volume of air entering the car engine**	

		increases with speed/ increase in air/ fuel ratio, more oxygen is drawn into the car, allowing a greater percentage of fuel to undergo complete combustion. However, as the speed increase from 80 km/h to 120km/h, **a larger mass of fuel is required for combustion as indicated** in the graph for hydrocarbon This results in **incomplete combustion due to limited amount of oxygen** being drawn in which **results in an increase in carbon monoxide produced**.	1 1 1
	d	$2CO + 2NO \rightarrow 2CO_2 + N_2$ $2NO_2 \rightarrow N_2 + 2O_2$ At the end of the reactions, NO and NO_2 are converted by the catalytic converter into **harmless gaseous products** as shown in the redox equations above.	1 1 1
			12

Section B			
9	**(a)**	$MgCO_3 + H_2SO_4 \rightarrow MgSO_4 + H_2O + CO_2$	
		Mr $MgCO_3$= 24 +12 +16(3) =84 No of mole of $MgCO_3$ = 4.33/ Mr $MgCO_3$ = 4.33/ 84 =0.0515 mol No of mole of sulfuric acid = M x V =0.200 mol/ dm^3 X 250/1000 dm^3 =0.0500 mol	1
		Mole ratio of H_2SO_4: $MgCO_3$ 1 : 1 0.05 : 0.05 Hence, **H_2SO_4 is the limiting reactant.** Mass of $MgSO_4$= 0.05 x Mr $MgSO_4$ = 0.05 x (24+ 32 + 16(4)) = 0.05 x120 **= 6.00 g**	1 1
	(b)	The hydrated crystals thermally decompose at high temperature or lose water of crystallization forming the anhydrous salt, $MgSO_4$.	1
	(c)	Mr of H_2O = 18, Mr $MgSO_4.7H_2O$ = 120 +7(18) =246 % by mass of water of crystallization = $\frac{7(18) \times 100\%}{246}$ = **51.2 %**	 1
	(d)	Add excess Magnesium/ Magnesium oxide/ Magnesium hydroxide to dilute sulfuric acid Filter the mixture. Concentrate the filtrate and leave to cool. Filter and rinise and dry the crystals.	1 1
	(e)	Add <u>any soluble radium salt</u> e.g. <u>aqueous</u> radium nitrate to <u>any soluble sulfate salt</u> e.g. sodium sulfate [1] <u>Filter</u> the mixture and <u>keep the residue</u>. [1] <u>Wash</u> <u>residue</u> with a <u>little distilled water</u>, and <u>press dry between sheets of filter paper</u>. [1]	3
			[10]

10	**(a)**	The zinc case oxidises to form zinc ions and electrons/ zinc loses electrons[1] At carbon rod, the hydrogen ions react with manganese(IV) oxide and electrons to form manganese(III) oxide and water [1] The flow of electrons from zinc to carbon rod creates the electricity. [1]	3
	(b)	Cathode (must state but no mark). Reduction occurred at carbon rod	1
	(c)	Zinc case is used up and contents in the cell leaks out. Ammonia gas produced from the dissociation of ammonium ions leaks out.	1
	(d)	Iron is less reactive than zinc	1
	(e)(i)	Lithium as an ion is very **stable** and has **a small relative atomic mass and radius** (third only to hydrogen and helium)/ possessed the highest energy density.	1
	(ii)	• Lithium reacts with water to form lithium hydroxide and hydrogen gas. $2Li + 2H_2O \rightarrow 2 LiOH + H_2$ Zinc does not react with water • Zinc forms an amphoteric oxide, can reacts with acid and alkali Lithium forms basic oxide, reacts with acid to form salt and water • Li is a stronger reducing agent than Zn. (any two) Or any possible answers	1 1 1
			[10]