

2024 Preliminary Examination H1 Chemistry (8873) Suggested Solutions

Paper 1

1	С	11	Α	21	Α
2	В	12	В	22	С
3	С	13	С	23	С
4	D	14	С	24	D
5	В	15	Α	25	Α
6	С	16	D	26	В
7	Α	17	D	27	D
8	Α	18	В	28	Α
9	D	19	Α	29	Α
10	В	20	В	30	D

Paper 2 Section A

1(a)	Number of neutrons	78 [0.5]	
	Number of electrongs	52 [0.5]	
(b)	Te ⁺ ion will be deflected towards the positive	ards the <u>negative</u> ly charged plate wh aly charged plate. Te atom will <u>not</u> be	ile the electron will be e deflected. [1]
	The angle of deflection of Te+	is much <u>smaller</u> than that for the ele	ctron. [1]
(c)(i)	Te (g) \rightarrow Te ⁺ (g) + e ⁻ [1]		
(c)(ii)	The first ionisation energy i	increases across Period 3 [0.5] as	s the <u>nuclear charge</u>
	Increases [0.5] while the shiel	Iding effect remains relatively consta	nt or effective nuclear
	electron across the period. [0	.5] .5]	ve the first outermost
(c)(iii)	The <u>paired electrons</u> in the p that it takes less energy to rem element. [1]	o orbital of Te experiences <u>inter-elec</u> nove the first outermost electron comp	ctronic repulsion such bared to the preceding
	Note: 4d electrons are poor a	t shielding the outer electrons from th	ne nuclear charge.

(d)(i)	
	ionisation energy/kJ mol ⁻¹
	0
	0 1 2 3 4 5 6 7 successive ionisation
	[0.5] general increase from 1 to 4
	[0.5] general increase from 5 to 6
	[0.5] jump from 4 to 5 [0.5] bigger jump from 6 to 7
(-1)(!!)	As shortness and successively remained from the To store, suclear shores remained the
(a)(II)	same or number of protons remain the same [0.5] but the remaining electrons
	experiences stronger attraction by nucleus or shielding effect decreases or increase in
	effective nuclear charge.[U.5]
(e)	There are <u>6 bond pairs</u> and <u>0 lone pairs</u> of electrons around Te. [1] The <u>6 electron pairs</u>
	are arranged as far apart as possible around Te to minimise repulsion and maximise stability. [1]
(f)(i)	$TeF_6 + 6H_2O \rightarrow Te(OH)_6 + 6HF [1]$
(f)(ii)	hydrolysis [1]
0(-)(!)	
2(a)(l)	NaCl [0.5] MgCl ₂ [0.5] [-0.5] for wrong entry
(a)(ii)	$A_1C_{l_3}$ and SiC_{l_4} and PC_{l_5} [0.5] for any 2 correct ones [1] for all 3
(b)(i)	-58.2 = 8 (264) + 4 (244) - 4 [264 + 2 (S-Cl)] [1] quote of the correct values
	<u>= 261</u> kJ mol ⁻¹ (3 s.f.) [1] multipliers
	[1] bond break – bond form, ecf
(b)(ii)	The enthalpy change when 1 mole of a substance is formed from its constituent elements
	in their standard states at 298 K and 1 bar. [1]
(b)(iii)	-58.2
	(3) + 4012(y) - 402012(1)
	$+4Cl_2(g)$ 8 X ΔH 4(-40.6) +4Cl_2(g)
	$8SCl_2(l)$

	$8 \times \Delta H_{\rm f} = -58.2 + 4(-40.6)$ [1] correct values at the arrows and
	$= -27.6 \text{ kJ mol}^{-1} $ [1] multipliers
	[1] apply the correct Hess' Law, ecf
(c)(i)	S_2Cl_2 is oxidised to SCl_2 ; oxidation number of sulfur increases from +1 to +2. [1] Cl_2 is reduced to SCl_2 ; oxidation number of chlorine decreases from 0 to -1. [1]
(c)(ii)	$Cl_2 + 2e^- \rightarrow 2Cl^-$ Charge on 1 mole of electron = 6.02 × 10 ²³ × (-1.60 × 10 ⁻¹⁹) = 96320 C [1] No. of moles of electrons = 2 × 1.5 = 3 mol [0.5] charge = 3 × 96320 = 288960 C ≈ 289000 C [0.5]
(c)(iii)	Position of equilibrium shifts to the <u>right</u> to <u>decrease the number of moles of gases</u> to offset the increase in pressure. [1]
	Equilibrium constant remains constant because it is only dependent on temperature [1]
(c)(iv)	<u>S-Cl bonds are polar</u> [1] and <u>individual dipoles do not cancel off</u> (or net dipole is not zero) so SC_{l_2} is a <u>polar</u> molecule. [1]
3(a)	The longer side chains in LDPE <u>hinders</u> the polymer chains <u>from coming close together</u> , resulting LDPE having <u>weaker dispersion forces</u> between the chains/molecules, so it is less strong / with less tensile strength and less useful. [1]
(b)	4-methylhex-1-ene [1] Propene
(C)	Addition peak at <u>700-800</u> cm ⁻¹ [1]
(d)(i)	C ₁₅ H ₁₀ O ₂ N ₂ [1]
(d)(ii)	$ \begin{array}{c c} & H \\ \hline \\ C \\ \hline \\ C \\ \hline \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$
(d)(iii)	<u>Water</u> molecules are able to form <u>hydrogen bonds</u> with the amide groups in the polyamide chains of Nylon-6, <u>disrupting</u> the existing <u>hydrogen bonds</u> between the chains and their arrangement. [1] When the water evaporates, <u>new hydrogen bonds are formed</u> between the chains, locking them in new positions, resulting in creases. [1] Polyesters like PET <u>do not form extensive hydrogen bonds with water</u> so the arrangement of the polymer chains are less disrupted hence they are less prone to creasing
	analigement of the polyment chains are less distupled hence they are less profile to cleasing.

4(a)	Sugarcane maybe considered to be 'carbon neutral' because during the process of
	photosynthesis, the plant <u>removes</u> carbon dioxide gas from the atmosphere. The fermentation of glucose to ethanol and the combustion of ethanol then <u>release</u> carbon dioxide gas back into the atmosphere. Overall, the process removes carbon dioxide gas from the atmosphere, and returns carbon dioxide gas to the atmosphere in the same quantities
	[1] explain how the amount of carbon remains the same from the source to the usage
	Ethanol produced by fermentation must be purified by distillation. Distillation requires high temperatures and hence requires energy which could come from the combustion of fossil fuels, a process which will <u>release</u> carbon dioxide gas into the atmosphere. OR
	Ethanol can also be prepared by an addition reaction between ethene and steam. This reaction <u>does not remove</u> any carbon dioxide gas from the atmosphere, but takes place at a high temperature (300°C) and pressure (70 atm.) which require a large amount of energy. This energy could be produced by burning fossil fuels which <u>releases</u> carbon dioxide gas into the atmosphere. [1] explain how the amount of carbon does not remain the same.
(b)(i)	For every 400 m of F00 fuel, there is 00 m of othereal
(1)(0)	For every 100 g of E80 fuel, there is 80 g of ethanol. Mass of oxygen in 100g of E80 fuel = $\frac{16}{10} \times 80 = 27.8$ g
	Percentage mass of oxygen = 27.8% [1]
(b)(ii)	An increased percentage of oxygen in the fuel means that more of the fuel will undergo complete combustion/burns completely. This will release more energy, making the fuel more efficient. OR
	This will reduce the levels of harmful / toxic pollutants e.g. carbon monoxide.
	This will require less oxygen for complete combustion. [1]
(c)	Ethanol <u>oxidises</u> in air to form <u>ethanoic acid</u> . [0.5] Both ethanoic acid and ethanol undergoes <u>esterification / condensation</u> to form ethyl ethanoate. [0.5]
(b)	$CCE ef DC = \frac{34200}{1.2} 1.2 1 eccent 1.20$
()	To release the same amount of energy as 1 L of petrol, and hence in order to travel the same distance as it would be travelled on 1 L of petrol, the vehicle would have to store 1.3 L of LPG. The storage tank that is required to store LPG must be 1.3 times greater than that to store petrol for the same amount of energy output/same distance travelled. [1] must use 1.3
(0)	
(e)	Wass of octane in 1L = $0.75 \frac{1}{cm^3} \times 1000 cm^3 = 750 g$
	Amount of octane in 1L = $\frac{1}{114.0}$ = 6.579 mol [0.5] Energy density per L of octane = 5470 × 6.579 = 36000 kJ/L [0.5]
	The energy density in Table 4.1 is for the fuel which contains a mixture of compounds / impurities while the approximate value assumes the fuel only contains octane as the only pure compounds. [1]
(f)(i)	(excess) concentrated sulfuric acid, heat [1]

H [×] [×] H _[1]
Reactant molecules are <u>adsorbed</u> onto the active sites on the surface of the catalyst by forming <u>weak interactions</u> . [1]
Adsorption brings reactant molecules closer together and weakens the covalent bonds
within the molecules, hence lowering the activation energy. [1]
After the reaction, the product molecules <u>desorb</u> from the surface and the active sites are <u>available for further reaction</u> . [1]
Nanomaterial is a material with <u>at least one dimension</u> on the nanoscale (1-100nm). Nanoparticle is a material with <u>all 3 dimensions</u> on the nanoscale (1-100nm). [1]
High surface area to volume ratio. [1]
[1] only 1 layer with at least 3 rings
Graphene has a macromolecular/giant covalent structure, where each carbon atom is <u>covalently bonded to 3 other C atoms</u> , with <u>one unbonded outer shell electron</u> . [1] The unpaired electrons become <u>delocalised</u> and <u>mobile</u> across the layer. This allows graphene to conduct electricity. [1]

Paper 2 Section B

5(a)(i)	$NaOH + HCl \rightarrow NaCl + H_2O$				
	$n(HCl) = \frac{50}{1000} \times 2 = 0.100 \text{ mol } [0.5] n(NaOH) = \frac{60}{1000} \times 1 = 0.0600 \text{ mol } [0.5]$				
	NaOH is the limiting reagent.				
	$n(HCl)$ left = $n(H^+)$ = 0.100 – 0.0600 = 0.0400 mol [0.5] ecf				
	$[H^+] = \frac{0.0400}{\frac{110}{1000}} = 0.364 \ [0.5] \text{ total volume, ecf}$				
	pH = -lg 0.364 = 0.439 [1] -lg application				
(a)(ii)	$n(NaOH) = n(H_2O) = 0.0600 mol$				
	Extrapolate the graph and $\Delta T = 12p-2p = 10p$ [1]				
	$\Delta H = -\frac{110 \times 4.18 \times (12p-2p)}{0.0600} = -76.6 \text{ p kJ mol}^{-1} \text{ [1] for correct q and [0.5] for } \Delta H + [0.5]$				
	Units				
(a)(iii)	Answer should be the same as (ii), in terms of p [0.5] The amount of water formed from				
	hydrochloric acid and sulfuric acid remains the same. [0.5]				
(a)(iv)	Energy is required to dissociate the weak acid to produce H ⁺ . [1]				

(a)(v)	BaSO ₄ which is a	precipitate is formed, so additional energ	y may be released/absorbed.	
	[1]			
(b)	The order of thermal stability is: $H-Cl > H-Br > H-I$ [0.5] <u>Down the group</u> , bond length of the H–X bond increases / size of halogen increases, less effective orbital overlap and <u>bond strength decreases</u> , hence <u>less energy is needed</u> to break the H–X bond. [1]			
	HC <i>l</i> does not dec HBr yields reddis HI gives violet fur	compose even on strong heating. [0.5] h-brown fumes of Br_2 under strong heating mes of I_2 when red-hot rod is plunged into	ng. [0.5] o jar of HI. [0.5]	
(c)	$n(CuI) = \frac{0.163}{(63.5+126)}$			
	n(Cu ²⁺) in 500 cm	$n(Cu^{2+})$ in 500 cm ³ = $\frac{500}{25} \times 0.000856 = 0.0171$ mol [0.5] ecf		
	$mass(Cu^{2+}) = 0.0$	171 × 63.5 = 1.09g [0.5]ecf		
	% mass = $\frac{1.09}{4.256}$ >	< 100 = 25.6% [0.5]ecf		
(d)(i)	$K_{c} = \frac{[I_{2}][H_{2}]}{[HI]^{2}}$ [1] no	units [1]		
	2			
(d)(ii)	$K_{\rm c} = \frac{[{\rm I}_2][{\rm H}_2]}{[{\rm HI}]^2} = \frac{{\rm x}^2}{(\frac{1.7}{5})^2} = 0.0217$ [1] concentration of HI			
	$[I_2] = 0.0500 \text{ mol}$	dm ⁻³ [1] ecf		
(d)(iii)	Since K_c is smaller, position of equilibrium shifts to the left [0.5] when temperature is lowered. When temperature is lowered, it will release heat to offset the decrease in temperature [0.5] and backward exothermic reaction is favoured. So the forward reaction is endothermic. [1]			
6(a)(i)	A.4. [4]	C ₆ H ₈ O ₇	NaHCO ₃	
	Mol ratio [0.5]	0.45	0.25	
		$\frac{1}{192} = 0.00234$	$\frac{1}{84} = 0.00297$	
	NaHCO ₃ is the lin	niting reagent. [0.5]		
		0.043		
(a)(II)	$n(CO_2) = n (NaHC)$	$(U_3) = \frac{1}{24} = 0.00179 \text{ mol } [1]$		
	mass (NaHCO ₃) = 0.150	= 0.00179 x 84 = 0.150 g		
	% yield = $\frac{3.130}{0.25} \times 1$	100 = 60.0% [1] ecf		

(b)(i)	H H H H
	$H = \begin{pmatrix} 0 & 0 \\ H & 0 \\ H & - \end{pmatrix} = \begin{pmatrix} 0 & - \\ H & 0 \\ H & - \end{pmatrix} = \begin{pmatrix} 0 & - \\ H & 0 \\ H & - \end{pmatrix} = \begin{pmatrix} 0 & - \\ H & - \\ H & - \end{pmatrix} = \begin{pmatrix} 0 & - \\ H & - $
(b)(ii)	Condensation [1]
(,()	
(c)	Sodium citrate has giant ionic structure/lattice [0.5] while citric acid has a simple molecular structure. [0.5]
	Sodium citrate has a high melting point because large amount of energy is required to break the strong ionic bonds between Na ⁺ and citrate ions. [0.5] However citric acid has a lower melting point because less amount of energy is required to break the weaker H bond / IMF / dispersion forces between the citric acid molecules. [0.5]
(d)(i)	Lactic acid is produced so pH is <u>lowered</u> . [1]
(-1) (::)	
(a)(II)	$H^+ + HCO_3^- \rightarrow CO_2 + H_2O$ [1] When a small amount of H^+ ions is added to the blood as a result of the production of lactic acid during exercise, the H^+ ions react with the large reservoir of the HCO_3^- ions in the blood. The ratio [HCO_3^-] / [CO_2] remains almost constant, hence pH remains relatively unchanged. [1]
(e)(i)	
	Rate A $[IO_3^-]$ [1]
(e)(ii)	$0.0420 = k (0.04)(0.0150)^2(0.0250)^2$ k = 7.47 x 10 ⁶ [1] mol ⁻⁴ dm ¹² min ⁻¹ [1]
(0)(;;;)	$0.0700 = 7.47 \times 106 \times 100 = 1 \times (0.00000)^2 (0.04000)^2 10.0100 = 10000000000000000000000000000$
(e)(III)	$[IO_3^-] = 0.120 \text{ mol } dm^{-3}[0.5]$ (0.0225) ² (0.0125) ² [0.5]SUDStitute
(e)(iv)	rate at pH 1.0 $(10^{-1})^2$ 400 [4] rotic [4] convers
*/\ `` /	$rate at pH 2.0 = [10^{-2}]^{-2} = 100 [1] ratio [1] square$

(e)(v)	When temperature is increased, the reactant particles have greater average kinetic
	energy. They move more quickly and so collide more frequently. More importantly, the
	number of particles that have energies greater than or equal to the activation energy
	increases. Frequency of effective collisions increase, hence rate of reaction increases.
	[1]