SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 1

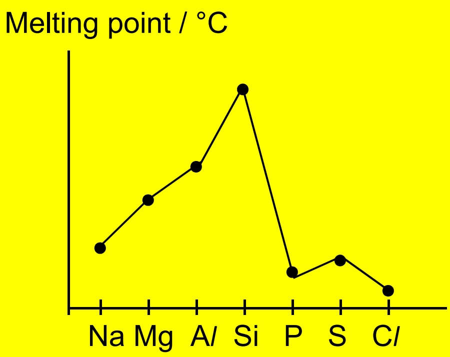
CHEMISTRY — 8873/02

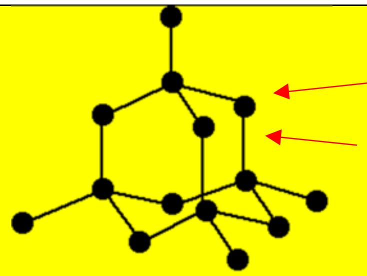
JC2 Preliminary Examination — **12 September 2018**

Paper 2 Structured Questions — **2 hours**

Section A

1	Combustion data can be used to calculate the empirical formula, molecular formula and relative molecular mass of many organic compounds.			
	(a)	Define the term *relative molecular mass*. [1]		
		Relative molecular mass is the **average mass of one molecule of the substance compared to $\frac{1}{12}$ the mass of an atom of carbon-12.** [1]		
	(b)	**B** is an alcohol, C_xH_yO. A 20 cm^3 gaseous sample of **B** was completely burnt in 200 cm^3 of oxygen (an excess). The final volume, measured under the same conditions as the gaseous sample, was 250 cm^3. Under these conditions, all water present was vaporised. Removal of the water vapour from the gaseous mixture decreased the volume to 170 cm^3. The remaining gaseous mixture was treated with concentrated alkali, and the eventual volume was decreased to 110 cm^3. Given the equation for the complete combustion of **B**, answer the questions below. $C_xH_yO + zO_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$		
		(i)	Calculate the value of ***x*** and ***y***. [2]	
			Volume of CO_2 = 170 – 110 = 60 cm^3 Using Avogadro's Law, $\frac{CxHyO}{CO2} = \frac{20}{60} = \frac{1}{x}$ ***x*** = 3 [1] Volume of water vapour = 250 – 170 = 80 cm^3 $\frac{CxHyO}{H2O} = \frac{20}{80} = \frac{1}{y/2}$ ***y*** = 8 [1]	
	(c)	Period 3 elements also react with oxygen to form oxides. Sodium oxide and sulfur dioxide are two such oxides.		

		(i)	Write chemical equations, with state symbols, when each of the above oxides react with water. [2]
			$Na_2O(s) + H_2O(l) \rightarrow 2NaOH(aq)$ **[1]** $SO_2(g) + H_2O(l) \rightleftharpoons H_2SO_3(aq)$ **[1]**
		(ii)	State and explain the pattern of change of oxidation number which occurs to both oxygen and the Period 3 elements (sodium to silicon) when they react together. [2]
			• The oxidation number of O does not change (-2 throughout). • Oxidation number of Na to Si increases from +1 to +4. • The number of oxygen attached to the element matches the respective group numbers **[2] for 2 points**
	(d)	The first ionisation energies of elements across Period 3 show a general increase. Aluminium and sulfur do **not** follow this general trend.	
		(i)	Write an equation to define the first ionisation energy of aluminium. [1]
			$Al\ (g) \rightarrow Al^{+}\ (g) + e$ **[1] with state symbols**
		(ii)	Explain the general increase in ionisation energy across Period 3. [2]
			Across period 3, **<u>nuclear charge increases</u>** while **<u>shielding effect is similar</u>**. **[1]** Thus, overall effective nuclear charge increases, resulting in **<u>stronger electrostatic forces of attraction between nucleus</u>** and valence **<u>electrons</u>**. **<u>More energy is needed to remove the electron</u>** **[1]** across Period 3.
		(iii)	Explain why aluminium has a lower first ionisation energy than magnesium. [1]
			Al: $[Ne]3s^2 3p^1$; Mg: $[Ne]3s^2$ Electron is **<u>removed from the outer 3p subshell for Al</u>**, which is **<u>further</u>** away from the attraction of the nucleus. Thus, less energy is needed to do so. **[1]**
	(e)	Silicon is an element in Period 3 displaying unique properties such as electrical conductivity at high temperatures and high melting point.	
		(i)	Complete the sketch of the melting point trend for Period 3 elements in **Figure 1.1**. [1]
			 **[1]**

		(ii)	With the aid of a well-labelled diagram, explain the abnormally high melting point of silicon, using concepts of structure and bonding. [3]
			 **[1] for labelled diagram** Silicon has a **giant covalent structure** **[1]** **with strong covalent bonds between Si atoms**. **A lot of energy** is needed to overcome these strong bonds, hence high melting point is observed. **[1]**
		(ii)	When silicon reacts with magnesium, Mg_2Si forms. Mg_2Si is thought to contain the Si^{4-} ion. State the full electronic configuration of Si^{4-}. [1]
			$1s^22s^22p^63s^23p^6$ **[1]**
		(iii)	Solid Mg_2Si reacts with dilute hydrochloric acid to form gaseous SiH_4 and a solution of magnesium chloride. Write an equation to show the reaction described above. Include state symbols. [1]
			$Mg_2Si\ (s) + 4HCl\ (aq) \rightarrow SiH_4\ (g) + 2\ MgCl_2\ (aq)$ **[1] with correct S.S.**
			[Total: 17]

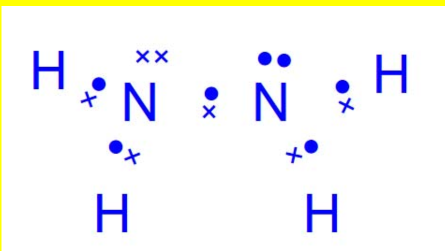
2 Hydrazine has many industrial uses such as rocket fuel, pesticides and to prepare gas precursors used in air bags. Liquid hydrazine undergoes combustion according to the following equation:

$$N_2H_4\ (l) + O_2\ (g) \rightarrow N_2\ (g) + 2H_2O\ (l)$$

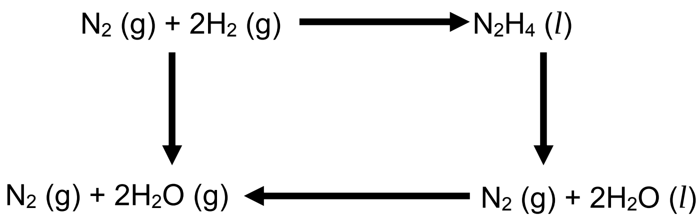
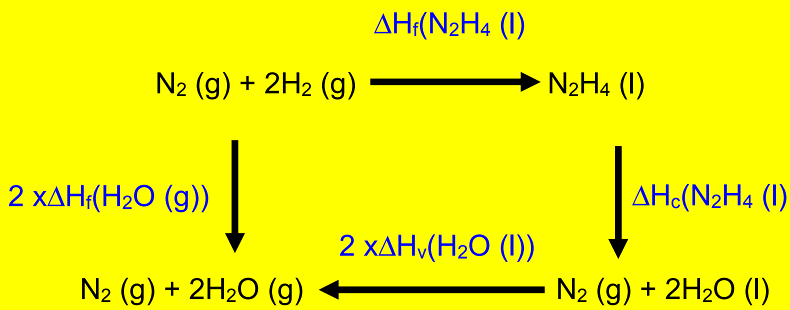
A chemist conducted an experiment to determine the standard enthalpy change of combustion of hydrazine where 0.420 g of hydrazine was burnt to heat up a beaker containing 200 cm^3 of water. The temperature of water in the beaker was recorded as follows:

Initial temperature /ºC	29.3
Final temperature / ºC	37.4

(a) (i) Draw the dot-and-cross diagram of hydrazine. [1]



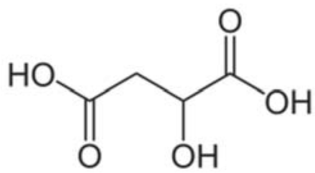
[1]

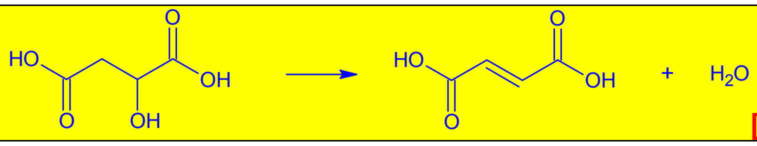
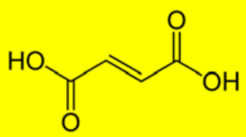
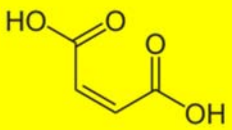
		(ii)	Explain what is meant by standard *enthalpy change of combustion of hydrazine.*	[1]
			Standard enthalpy change of combustion (ΔH_c^θ) of hydrazine is the **<u>energy released</u>** when **<u>one mole of the hydrazine</u> is <u>completely burnt in oxygen</u> at <u>(standard conditions) 298K and 1 atm</u>.** **[1]**	
		(iii)	Calculate the standard enthalpy change of combustion of hydrazine. You may assume the process has 80 % efficiency	[2]
			Q = 200 x (37.4 – 29.3) x 4.18 = 6771.6 J Amount of heat released by reaction, Q' = Q / 0.8 = 8464.5 J **[1]** No of moles of N_2H_4 = 0.420 / 32 = 1.313 x 10^{-2} mol $\Delta H_c(N_2H_4)$ = − 6771.6 / 1.313 x 10^{-2} = − 644914 J mol^{-1} = **<u>−645 kJ mol^{-1}</u>** **[1]**	
		(iv)	Given the following data: enthalpy change of formation of steam = −242 kJ mol^{-1} enthalpy change of vapourisation of water = +44 kJ mol^{-1} Using the value you have calculated in **(iii),** complete the following energy cycle to determine the standard enthalpy of formation of hydrazine.	
				[2]
			 **M[1]** By Hess' law, ΔH_f ($N_2H_4(l)$) = 2(−242) – (−645) – 2(+44) = **<u>+ 73.0 kJmol^{-1}</u>** **[1]**	

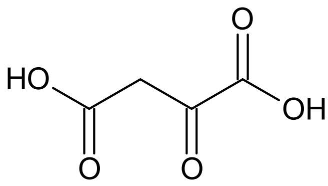
	(b)	**(i)**	The standard enthalpy change of formation of hydrazine gas is +235 kJ mol^{-1}. Using appropriate data from the *Data Booklet*, calculate the bond energy of N−H in hydrazine gas.	[2]
			ΔH_f (N_2H_4) = [944 + 2(436)] – [(160) + 4 x B.E(N−H)] + 235 +(+160) + 4 x B.E(N−H) = +944 + 2(+436) [M1] B.E (N−H) = +**355 kJ mol^{-1}** **[1]**	
		(ii)	Suggest a reason for the difference in the N−H bond energy value obtained from **(b)(i)** with the value given in the *Data Booklet*.	[1]
			The bond energy values obtained from the Data Booklet are **average values** and would differ from the experimental values. **[1]**	
			[Total: 9]	

3	This question is about nanoparticles and its applications.		
	(a)	Finely divided nanoparticles of nickel is found to be an extremely good heterogeneous catalyst for many organic synthesis reactions.	
		(i)	Define the term *catalyst*. **[1]**
			a substance that **increases the rate of a chemical reaction by providing an alternative pathway with a lower activation energy, itself being chemically unchanged.** **[1]**
		(ii)	State the difference between a *nanoparticle* and a *nanomaterial*. **[1]**
			Nanoparticles **ALL dimensions 1 to 100 nm on the nanoscale** Nanomaterial (**at least) one dimension 1 to 100 nm on the nanoscale**. **[1]**
		(iii)	Briefly explain how nickel **nanoparticles** operate as a **catalyst**. **[2]**
			Nanoparticles have **higher surface area to volume ratio**, total surface energy increases with overall surface area. **More nickel atoms are exposed** to the reactants. **[1]** **Frequency of effective collisions** between the reactants and catalyst **increases**. **Rate of reaction increases**. **[1]**
	(b)	One study found that 85 % of sunscreens available in Singapore are likely to contain titanium dioxide nanoparticles due to its ability to block UV radiation while remaining transparent on the skin.	
		(i)	Although the health risk posed by these sunscreen creams is minimal, this is not so for aerosol spray sunscreens. Suggest a reason why aerosol spray sunscreens pose a greater health risk. **[2]**
			Aerosol cans release the nanoparticles in the form of vapour/mist, which are easily inhaled. **[1]**

	(c)	Geckoes and many insects have adopted nanoscale fibrillary structures on their feet as adhesion devices. Many have the remarkable ability to run at any orientation on just about any smooth or rough, wet or dry, clean or dirty surface.
		Using your understanding of molecular forces, suggest why a gecko can support its own weight and stick to the wall. **[3]**
		On coming in contact with any surface, the nanostructure (spatula) on the gecko legs deforms to enable maximum contact with the wall surface, **forming instantaneous dipole-induced dipole interaction**. [1] As the spatula possesses **high surface to volume ratio** and there are billions of spatula per gecko, this creates a **huge collective surface area of contact**. [1] The cumulative spatula-wall forces of attraction generated is therefore translated into **enormous attractive (adhesive) forces** capable of supporting many times the animal's body weight. [1]
		[Total: 8]

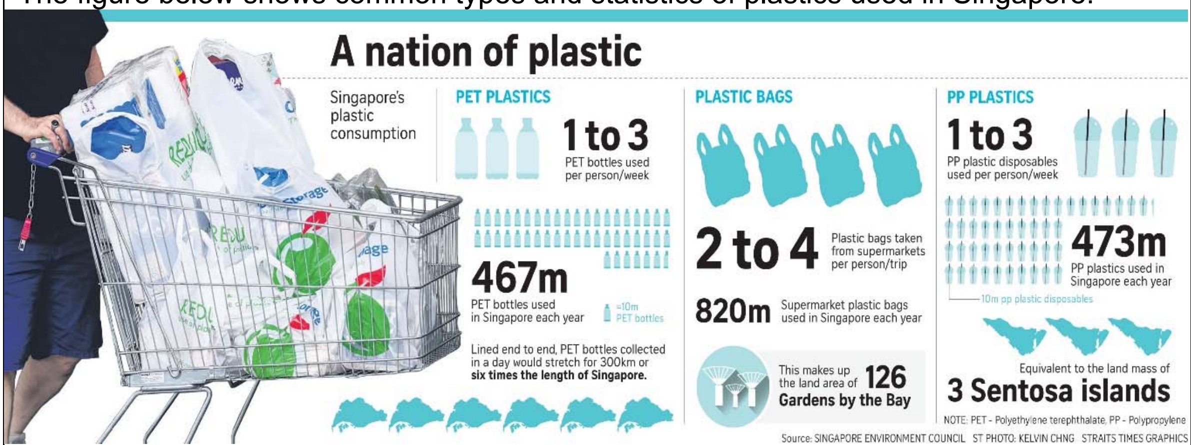
4	Acids are an important component in both winemaking and the finished product of wine. They have a direct influence on the colour and taste of the wine. The measure of the amount of acid in wine is known as the "total acidity". A label on a bottle of wine describes it as having a "total acidity" of 5.8 g dm^{-3}.			
	(a)	**(i)**	The acids found in wine behave as *Brønsted-Lowry acids*. Define a *Brønsted-Lowry acid*.	[1]
			proton donors [1]	
		(ii)	One of the most common acid present in wine is malic acid.  **malic acid** M_r = 134.0 K_a = 3.98 x 10^{-4} mol dm^{-3} Assuming that malic acid behaves effectively as a monobasic acid, RCOOH. Write an equation to show the dissociation of malic acid.	[1]
			$RCOOH \rightleftharpoons RCOO^- + H^+$ [1]	
		(iii)	Calculate the concentration in, mol dm^{-3}, of malic acid and the pH of the wine.	[2]
			[ROOH] = $\frac{5.8}{134}$ = 0.04328 mol dm^{-3} [1]	

			$K_a = \frac{[H^+][ROO^-]}{[RCOOH]}$ $K_a = \frac{[H^+]^2}{[RCOOH]}$ $[H^+] = \sqrt{K_a \times [RCOOH]} = \sqrt{3.98 \times 10^{-4} \times 0.04328}$ $= 0.004150 \text{ mol dm}^{-3}$ pH = **<u>2.38</u>** **[1]**
		(iv)	The dissociation of malic acid is endothermic. Explain the impact on its pH **and** K_a when temperature increases. [3]
			The dissociation of malic acid is an endothermic process. By LCP, the **<u>equilibrium position</u>** will **<u>shift right</u>** to favour the endothermic forward reaction to **<u>absorb heat</u>**.**[1]** **<u>[H⁺] increases</u>**, [RCOOH] decreases. Thus, **<u>pH decreases</u>**. **[1]** **<u>K_a will increase</u>** **[1]** as well.
		(v)	During the ingestion of wine, mouth saliva interacts with it through a buffering action involving CO_3^{2-} / HCO_3^-. Use an equation to illustrate how the buffer system in saliva maintains pH when wine is consumed. [1]
			$CO_3^{2-} + H^+ \rightarrow HCO_3^-$ **[1]**
	(b)	Malic acid undergoes elimination with concentrated sulfuric acid.	
		(i)	Write a balanced equation for the reaction that took place. [1]
			 **[1]**
		(ii)	Draw two possible isomers formed in **(b)(i)** and state the type of isomerism. [2]
			Cis-trans [1] isomerism  **Trans**  **Cis** **[1] for both structures**

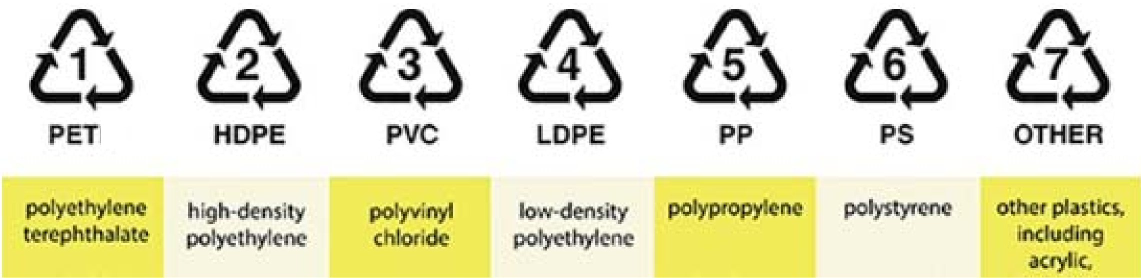
	(d)	Suggest the reagent required for the synthesis of malic acid from the following compound.  [1]
		$NaBH_4$ in ethanol or H_2, Ni catalyst and heat [1] Note: Cannot use $LiAlH_4$ as –COOH group will be reduced as well
		[Total: 12]

5 Singapore uses almost one plastic item per person per day, but fewer than 20% of these are recycled, according to the Singapore Environment Council (SEC). According to the National Environment Agency (NEA), only 6% by mass of plastics are recycled.

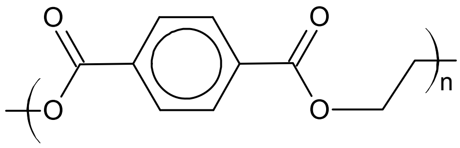
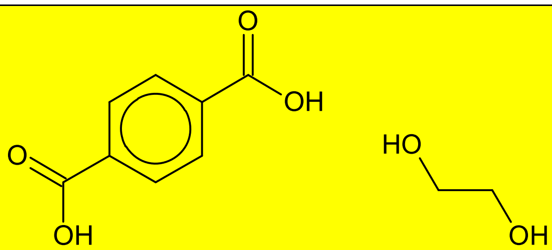
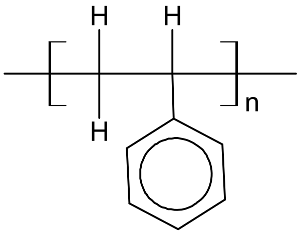
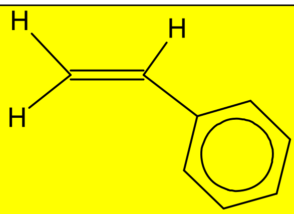
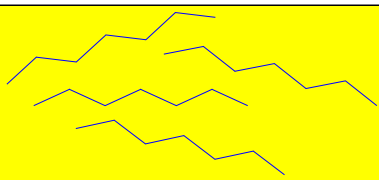
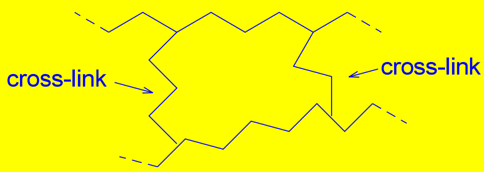
The figure below shows common types and statistics of plastics used in Singapore:



The ASTM International Resin Identification Coding System, often abbreviated as the RIC, is a set of symbols appearing on plastic products that identify the plastic resin out of which the product is made. Understanding the seven plastic codes will make it easier to choose plastics and to know which plastics to recycle:



The methods to reduce on waste in Singapore follows the three "Rs" – Reduce, Reuse and Recycle. However, not all plastics can be reused or recycled.

	According to some environmental watch groups, in order for a material to be reused, especially with applications on food and drink, it should not leach compounds that are toxic to human consumption (e.g. benzene derivatives). In order for a material to be recycled, it must be able to be melted and remoulded under high heat, and not decompose or char.		
	(a)	**(i)**	PET polymers are thermoplastics and are observed to have the repeat unit shown below.  Draw the monomer of PET and suggest the classification of this polymerisation. **[2]**
			 **[1] for both** Condensation polymer **[1]**
		(ii)	PS polymers are thermosets and are observed to have the repeat unit shown below.  Draw the monomer of PS and suggest the classification of this polymerisation. **[2]**
			 **[1]** Addition polymer **[1]**
		(iii)	With the aid of a simple well-labelled diagram, explain how thermoplastics differ from thermosets in their bonding between polymer chains. **[2]**
			 **Thermoplastic** **[1]**  **Thermoset**

			[1] Thermoplastic polymer has little or **no cross links between chains** and have **weak instantaneous dipole – induced dipole interactions between its chains** **[1]** while thermosetting polymers are **highly cross linked by strong covalent bonds formed between chains.** **[1]**
		(iv)	State if PET and PS can be recycled or reused. **[1]**
			PET can be recycled, but not reused. PS can cannot be recycled nor reused. **[1] for both**
	(b)	Explain the relative rigidity and state possible uses of both LDPE and HDPE. **[3]**	
		LDPE has **branching** on the chains cannot be packed closely together thus creating space between polymer chains resulting in **weaker intermolecular forces of attraction.** HDPE has **straight chain** configuration, the chain of polymer are packed closely together. **Extensive intermolecular forces of attraction** between the chain. **[1]** Hence **HDPE is more rigid than LDPE** **[1]** HDPE is used in pipes or detergent bottles, while LDPE is used as plastic grocery bags. **[1]**	
	(c)	A school performed a survey on 1000 students and 200 staff members. The survey found that the average person in school would purchase a drink in a plastic cup, and use two pieces of plastic crockery, for lunch every day. Each of those items used had a symbol emblazoned at the base shown below.  Identify the polymer used, and calculate the percentage waste contributed by this school in a year in relation to the type of polymer resin used. **[2]**	
		Poly(propene) Polypropylene/ PP **[1]** No. of plastic items used by each person = 3 (a plastic cup amd 2 pcs of crockery) Total number of plastics disposed in a year by 1200 students and staff = 3 x (1000 + 200) x 365 = 1314000 % waste = 1314000 / 473000000 x 100% = **0.278%** **[1]**	
		[Total: 14]	

Section B

<table>
<tr><td>6</td><td>(a)</td><td colspan="2">Transition metals are used in many commercial applications such as catalysts. The manufacture of sulfuric acid via the Contact process uses vanadium(V) oxide as catalyst.

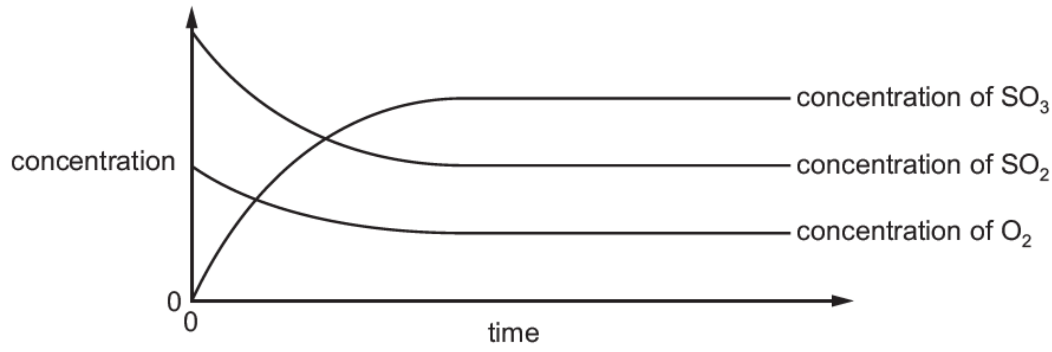
Stage one of this process involves the conversion of sulfur dioxide into sulfur trioxide.

$2SO_2\,(g) + O_2\,(g) \rightleftharpoons 2SO_3\,(g) \qquad \Delta H = -196\ \text{kJ mol}^{-1}$

2.00 moles of $SO_2(g)$ and 2.00 moles of $O_2(g)$ are sealed in a 40 dm^3 container with the addition of catalyst, at constant temperature and pressure. The resulting equilibrium contains 1.98 moles of $SO_3(g)$.</td></tr>
<tr><td></td><td></td><td>(i)</td><td>Use the information above to calculate the K_c value for the reaction, stating its units clearly.
[3]</td></tr>
<tr><td></td><td></td><td></td><td>
<table>
<tr><td></td><td>$2SO_2$</td><td>O_2</td><td>$2SO_3$</td></tr>
<tr><td>I / mol</td><td>2.00</td><td>2.00</td><td>0</td></tr>
<tr><td>C / mol</td><td>-1.98</td><td>- (1.98 / 2)</td><td>+1.98</td></tr>
<tr><td>E / mol</td><td>0.02</td><td>1.01</td><td>1.98</td></tr>
</table>
[1] for working
$K_c = \frac{[SO3]^2}{[SO2]^2[O2]} = \frac{\left(\frac{1.98}{40}\right)^2}{\left(\frac{0.02}{40}\right)^2\left(\frac{1.01}{40}\right)} =$ <u>3.88 x 10^5 [1] $mol^{-1}\ dm^3$ [1]</u></td></tr>
<tr><td></td><td></td><td>(ii)</td><td>State and explain the effect of increasing pressure on the rate of production of SO_3.
[2]</td></tr>
<tr><td></td><td></td><td></td><td>When pressure is increased, there are <u>more number of reactant particles per unit volume</u>, resulting in <u>more effective collisions</u>. [1]

Since <u>rate of reaction is proportionate to number of effective collisions, rate of production increases</u>. [1]</td></tr>
<tr><td></td><td></td><td>(iii)</td><td>State and explain the effect of increasing pressure on the yield of SO_3.
[2]</td></tr>
<tr><td></td><td></td><td></td><td>By LCP, when pressure increases, <u>position of equilibrium shifts to the right to product fewer molecules of gas,</u> [1] to decrease pressure. Thus, <u>yield of SO_3 increases.</u> [1]</td></tr>
<tr><td></td><td></td><td>(vi)</td><td>Another experiment of stage one was carried out.

The following graph showing how the concentrations of the three species in the system change with time was sketched.</td></tr>
</table>



Study the graph and explain the following:

(I) The gradients of the SO_2 and O_2 lines decrease with time

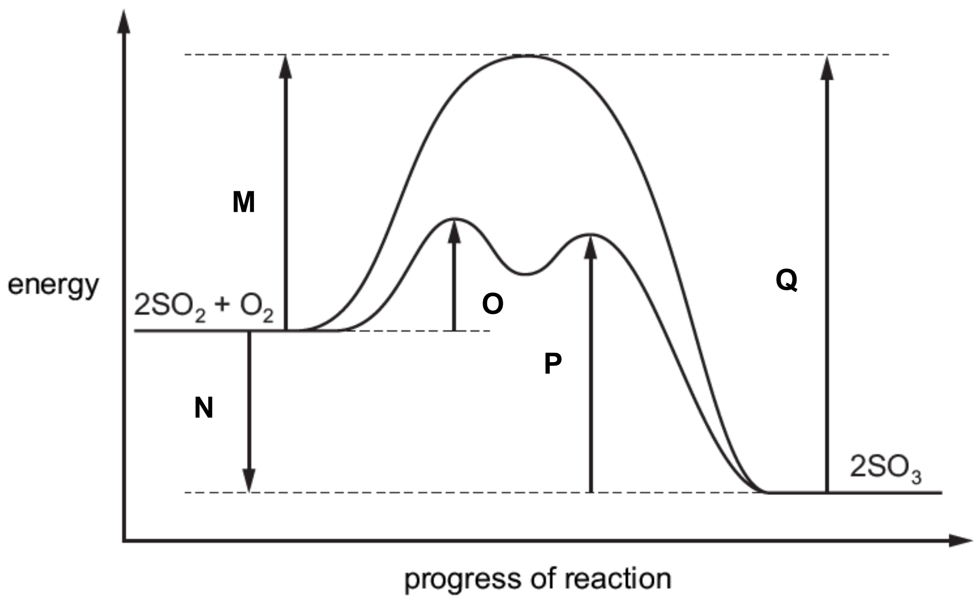
(II) The initial gradient of the SO_2 line is steeper than that of the O_2 line

[2]

(I) This is due to **decreasing concentrations** of the **reactants (or SO_2 and O_2)** as reaction progresses, so **rate of reaction decreases**. [1]

(II) The **mole ratio of SO_2 to O_2 is 2:1 / there is 2 times more mol of SO_2 than O_2**, thus **SO_2 is used up / reacted twice as fast** than O_2. [1]

(v) A reaction pathway diagram for both the catalysed and uncatalysed reactions of stage one is shown.



The letters **M – Q** represent energy changes.

Complete the table by stating which letter, **M – Q**, represents the energy change described.

energy change	letter
the energy change for the production of SO_3	
the activation energy for the production of SO_3 in the absence of a catalyst	
the activation energy for the first step in the **decomposition** of SO_3 in the presence of a catalyst	

[3]

N, M and P respectively **[1] each , total [3]**

(b) Transition metal manganese present in strong oxidising agents such as potassium manganate(VII), and used in many organic chemistry applications.

Butan-2-ol was heated with acidified potassium manganate(VII) to produce **R**.

$$CH_3CH(OH)CH_2CH_3 \xrightarrow{\mathrm{I}} \underset{\mathbf{R}}{CH_3COCH_2CH_3}$$

(i) Write a balanced equation for reaction **I**. [1]

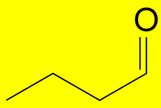
$CH_3CH(OH)CH_2CH_3 + 2[O] \rightarrow CH_3COCH_2CH_3 + H_2O$ **[1]**

(ii) There are two constitutional isomers of **R**, which are also carbonyl compounds. In the boxes below, draw the skeletal formulae of the isomers of **R**.

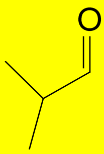
[2]

The 2 isomers are:
$CH_3CH_2CH_2CHO$ and $(CH_3)_2CHCHO$

Skeletal formulae (marks will only be awarded for this):



[1]



[1]

(iii) Suggest an alternative reagent and condition for reaction **I**. [1]

$K_2Cr_2O_7$ in H_2SO_4 (aq), heat / reflux **[1]**

	(c)	Mohr's salt, $(NH_4)_2Fe(SO_4)_2{\cdot}xH_2O$, is a hydrated form of ammonium iron(II) sulfate, where ***x*** represents the number of moles of water in 1 mole of the salt. A student wanted to determine the value of ***x***. 0.784 g of the hydrated salt was dissolved in water and 10 cm^3 of sulphuric acid was added. All of the solution was titrated with 0.0200 mol dm^{-3} potassium manganate(VII) where 20.00 cm^3 of potassium manganate(VII) solution was required for the complete reaction with the Fe^{2+} ions.		
		(i)	Use changes in oxidation number, or otherwise, balance the equation for the reaction taking place. MnO_4^- (aq) + ….Fe^{2+} (aq) + ….H^+ (aq) → ….Mn^{2+} (aq) + ….Fe^{3+} (aq) + ….H_2O (*l*) [1]	
			MnO_4^- (aq) + 5Fe^{2+} (aq) + 8H^+ (aq) → 1Mn^{2+} (aq) + 5Fe^{3+} (aq) + 4H_2O (*l*) **[1]**	
		(ii)	Calculate the amount of Fe^{2+} in the sample of the salt. [1]	
			Amount of MnO_4^- = 20/1000 x 0.0200 = 0.0004 mol Amount of Fe^{2+} = 5 x 0.0004 = **0.002 mol** **[1] allow ecf**	
		(iii)	Calculate the relative formula mass of $(NH_4)_2Fe(SO_4)_2{\cdot}xH_2O$ and hence, determine the value of x. [2]	
			Mole ratio: 1 $(NH_4)_2Fe(SO_4)_2{\cdot}xH_2O$ ≡ 1 Fe^{2+} 0.002 $(NH_4)_2Fe(SO_4)_2{\cdot}xH_2O$ ≡ 0.002 Fe^{2+} Using formula, n = $\frac{mass}{Mr}$ 0.002 = $\frac{0.784}{Mr}$ M_r = **392.0** **[1]** 392.0 = 2(14) + 8(1) + 55.8 + 2(32) + 8(16) + x(2+16) x = **6** **[1]**	
			[Total: 20]	

7	(a)		Samples of 2-bromopropane were dissolved in dilute aqueous ethanol and reacted with potassium hydroxide solution. Several experiments were carried out at constant temperature. The initial rate of reaction was determined in each case.

Expt	$[(CH_3)_2CHBr]$ / mol dm^{-3}	$[OH^-]$ / mol dm^{-3}	Rate / mol dm^{-3} s^{-1}
1	0.015	0.015	13.5
2	0.015	0.030	13.5
3	0.030	0.045	27.0

(i) Determine the order of reaction with respect to 2-bromopropane and potassium hydroxide. [2]

Comparing Expt 1 and 2,
By **keeping $[(CH_3)_2CHBr]$ constant and doubling $[OH^-]$, rate was constant**.
Hence, order of reaction wrt to $[OH^-]$ is **ZERO**. **[1]**

Comparing Expt 1 and 3,
By **tripling $[OH^-]$, rate remains constant.**
By doubling $[(CH_3)_2CHBr]$, rate was doubled.
Hence, order of reaction wrt to $[(CH_3)_2CHBr]$ is **ONE**. **[1]**

(ii) Hence, write the rate equation and determine the rate constant, indicating the units clearly. [2]

Rate = k $[(CH_3)_2CHBr]$ **[1]**

From Expt 1 data, 13.5 = k (0.015)
k = **900 s^{-1}** **[1]**

(iii) In another experiment, 2-bromopropane was reacted **hot aqueous** potassium hydroxide solution instead.

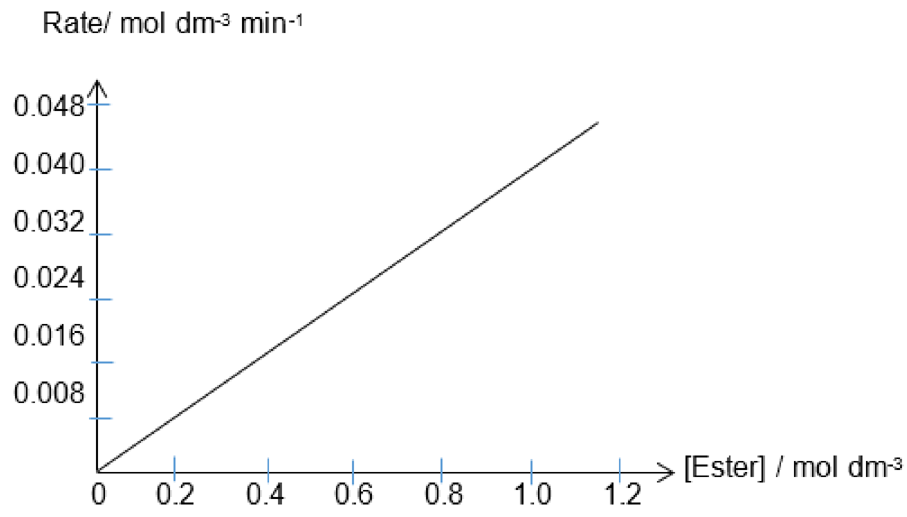
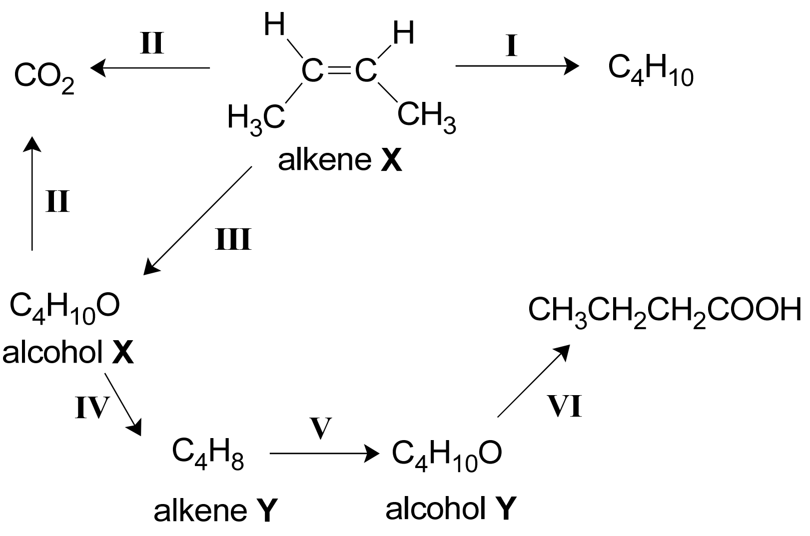
Write a balanced equation for the reaction that occurs. [1]

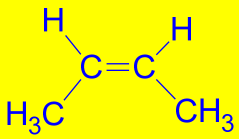
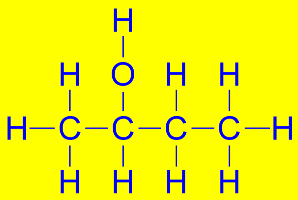
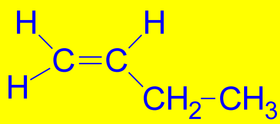
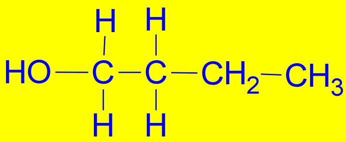
$CH_3CHBrCH_3$ + KOH → $CH_3CH(OH)CH_3$ + KBr **[1]**

nucleophilic substitution happens, instead of elimination

(b) A series of experiments was conducted to investigate the kinetics of the hydrolysis of an ester.

The graph below shows the results obtained when concentration of the ester were varied with the addition of large quantity of water at 400K. Order of reaction with respect to the ester is one.

			
		(i)	Using the graph, determine the value of rate constant, *k*. [1]
			The **gradient** of the graph is the rate constant, *k*. Rate constant, k = 0.032 / 0.8 = <u>**0.0400**</u> min^{-1} **[1] no need units**
		(ii)	Predict how the gradient of the graph would change at 500 K. Explain your answer. [3]
			The gradient will become <u>**steeper**</u> **[1]** When temperature of the reaction increases, • <u>**average kinetic energy**</u> of the reactant particles <u>**increases**</u> • <u>**more reactant particles with energy ≥ E_a**</u> Above 2 points **[1]** • <u>**more effective collisions**</u> • Since rate of reaction is proportional to the frequency of effective collisions, <u>**rate**</u> of reaction <u>**increases**</u> Above 2 points **[1]**
	(c)		

		(i)	Construct a balanced chemical equation for reaction **II**. [1]
			Combustion  $+ \ 6O_2 \longrightarrow 4CO_2 + 4H_2O$ **[1]**
		(ii)	When alkene **X** undergoes reaction with water in the presence of an acid catalyst, alcohol **X**, a secondary alcohol, is produced. Draw the displayed formula of alcohol **X**. Hence, name the carbonyl compound that can be reduced to form this alcohol [2]
			 **[1] displayed formula only** butanone **[1]**
		(iii)	Draw the structural formula of alkene **Y** and alcohol **Y**. [2]
			Alkene Y:  [1] Alcohol Y:  [1] FYI: • Alkene **Y** is a positional isomer of alkene **X** • alcohol **Y** is **<u>primary ROH</u>**, since alcohol **X** is secondary alcohol
		(iv)	Acidified potassium manganate(VII) was used in the oxidation process of alcohol **Y** to butanoic acid, as seen in reaction **VI**. The oxidation half-equation for the reaction is shown below. $C_4H_{10}O + H_2O \longrightarrow CH_3CH_2CH_2COOH + 4H^+ + 4e$ With an aid of a *Data Booklet*, construct an overall balanced chemical equation for reaction **VI** and determine the volume of 1.25 mol dm^{-3} potassium manganate(VII) required to oxidise 15 g of alcohol **Y**. [3]
		oxidation : $C_4H_{10}O + H_2O \longrightarrow CH_3CH_2CH_2COOH + 4H^+ + 4e$ (x5) reduction: $MnO_4^- + 8H^+ + 5e \longrightarrow Mn^{2+} + 4H_2O$ (x4) Overall equation: $5C_4H_{10}O + 4MnO_4^- + 12H^+ \longrightarrow 5CH_3CH_2CH_2COOH + 4Mn^{2+} + 11H_2O$ **[1]**	

Amt of alcohol **Y** = 15/ (4(12) + 10(1) + 16) = 0.2027 mol

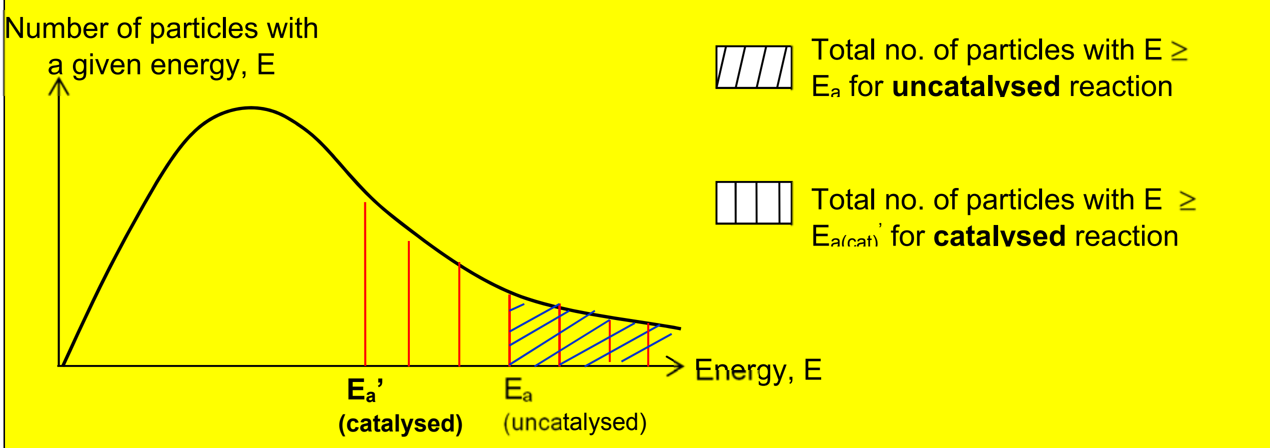
Since $5C_4H_{10}O \equiv 4MnO_4^-$,
Amt of MnO_4^- = (4/5) x 0.2027 = 0.1622 mol **[1]**

Volume of MnO_4^- required = 0.1622 / 1.25
= **<u>0.130 dm³ (or 130 cm³)</u>** **[1]**

(v) Platinum acts as catalyst in reaction **I**.

With an aid of a Maxwell Boltzmann distribution diagram, explain how platinum increases the rate of reaction.

[3]



Platinum is a catalyst with provide an alternative reaction pathway with lower activation energy.

When a catalyst is present,

- **<u>more reactant particles with energy ≥ Ea'(catalysed)</u>** leading to **<u>more effective collisions</u>**
- Since **<u>rate of reaction is proportional to the frequency of effective collisions,</u>**
- **<u>rate of reaction increases</u>**

any mistakes -1 mark, total [3]

[Total: 20]

END