SQA Higher Chemistry

Past Paper 2010

Marking guide include at end of paper.

5. 1 mol of hydrogen gas and 1 mol of iodine vapour were mixed and allowed to react. After t seconds, 0·8 mol of hydrogen remained.

The number of moles of hydrogen iodide formed at t seconds was

A 0·2

B 0·4

C 0·8

D 1·6.

7. Which of the following is **not** a correct statement about the effect of a catalyst?

The catalyst

A provides an alternative route to the products

B lowers the energy that molecules need for successful collisions

C provides energy so that more molecules have successful collisions

D forms bonds with reacting molecules.

8. A potential energy diagram can be used to show the activation energy (E_A) and the enthalpy change (ΔH) for a reaction.

Which of the following combinations of E_A and ΔH could **never** be obtained for a reaction?

A $E_A = 50\,kJ\ mol^{-1}$ and $\Delta H = -100\,kJ\ mol^{-1}$

B $E_A = 50\,kJ\ mol^{-1}$ and $\Delta H = +100\,kJ\ mol^{-1}$

C $E_A = 100\,kJ\ mol^{-1}$ and $\Delta H = +50\,kJ\ mol^{-1}$

D $E_A = 100\,kJ\ mol^{-1}$ and $\Delta H = -50\,kJ\ mol^{-1}$

9. As the relative atomic mass in the halogens increases

A the boiling point increases

B the density decreases

C the first ionisation energy increases

D the atomic size decreases.

10. The table shows the first three ionisation energies of aluminium.

Ionisation energy/kJ mol^{-1}		
1st	**2nd**	**3rd**
584	1830	2760

Using this information, what is the enthalpy change, in kJ mol^{-1}, for the following reaction?

$$Al^{3+}(g) + 2e^- \rightarrow Al^{+}(g)$$

A +2176

B −2176

C +4590

D −4590

11. When two atoms form a non-polar covalent bond, the two atoms **must** have

A the same atomic size

B the same electronegativity

C the same ionisation energy

D the same number of outer electrons.

12. In which of the following liquids does hydrogen bonding occur?

A Ethanoic acid

B Ethyl ethanoate

C Hexane

D Hex-1-ene

13. Which line in the table shows the correct entries for tetrafluoroethene?

	Polar bonds?	**Polar molecules?**
A	yes	yes
B	yes	no
C	no	no
D	no	yes

14. Element **X** was found to have the following properties.

(i) It does not conduct electricity when solid.

(ii) It forms a gaseous oxide.

(iii) It is a solid at room temperature.

Element **X** could be

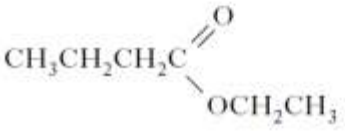
A magnesium

B silicon

C nitrogen

D sulphur.

19. Rum flavouring is based on the compound with the formula shown.



It can be made from

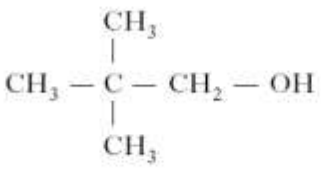
A ethanol and butanoic acid

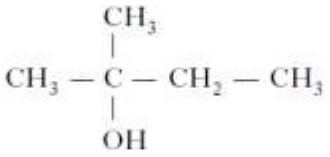
B propanol and ethanoic acid

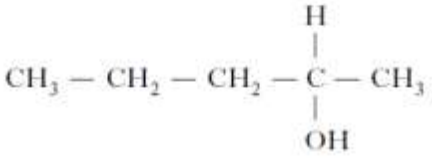
C butanol and methanoic acid

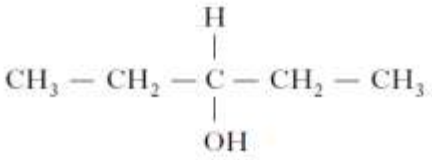
D propanol and propanoic acid.

20. Which of the following structural formulae represents a tertiary alcohol?

A 

B 

C 

D 

21. What is the product when one mole of chlorine gas reacts with one mole of ethyne?

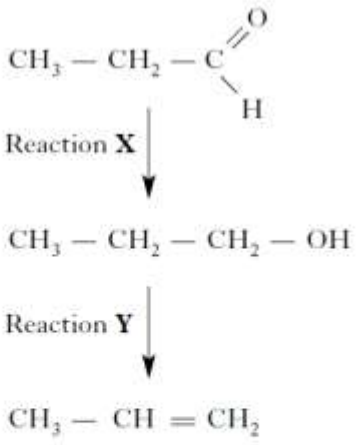
A 1,1-Dichloroethene

B 1,1-Dichloroethane

C 1,2-Dichloroethene

D 1,2-Dichloroethane

22.



Which line in the table correctly describes reactions **X** and **Y**?

	Reaction X	**Reaction Y**
A	oxidation	dehydration
B	oxidation	condensation
C	reduction	dehydration
D	reduction	condensation

28. Which of the following fatty acids is unsaturated?

A $C_{19}H_{39}COOH$

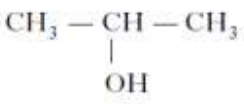
B $C_{21}H_{43}COOH$

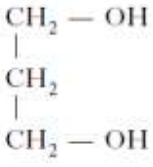
C $C_{17}H_{31}COOH$

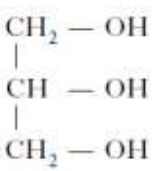
D $C_{13}H_{27}COOH$

29. Which of the following alcohols is likely to be obtained on hydrolysis of butter?

A $CH_3 - CH_2 - CH_2 - OH$

B 

C 

D 

30. Amino acids are converted into proteins by

A hydration

B hydrolysis

C hydrogenation

D condensation.

32. Given the equations

$Mg(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$ $\Delta H = a\ J\ mol^{-1}$

$Zn(s) + 2H^+(aq) \rightarrow Zn^{2+}(aq) + H_2(g)$ $\Delta H = b\ J\ mol^{-1}$

$Mg(s) + Zn^{2+}(aq) \rightarrow Mg^{2+}(aq) + Zn(s)$ $\Delta H = c\ J\ mol^{-1}$

then, according to Hess's Law

A $c = a - b$

B $c = a + b$

C $c = b - a$

D $c = -b - a$.

33. In which of the following reactions would an increase in pressure cause the equilibrium position to move to the left?

A $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$

B $CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$

C $Fe_2O_3(s) + 3CO(g) \rightleftharpoons 2Fe(s) + 3CO_2(g)$

D $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

34. If ammonia is added to a solution containing copper(II) ions an equilibrium is set up.

$Cu^{2+}(aq) + 2OH^-(aq) + 4NH_3(aq) \rightleftharpoons Cu(NH_3)_4(OH)_2(aq)$ (deep blue)

If acid is added to this equilibrium system

A the intensity of the deep blue colour will increase

B the equilibrium position will move to the right

C the concentration of $Cu^{2+}(aq)$ ions will

DO NOT WRITE IN THIS MARGIN

Marks

SECTION B

All answers must be written clearly and legibly in ink.

1. The elements lithium, boron and nitrogen are in the second period of the Periodic Table.

Complete the table below to show **both** the bonding and structure of these three elements at room temperature.

Name of element	Bonding	Structure
lithium		lattice
boron		
nitrogen	covalent	

2

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Marks

3. Atmospheric oxygen, $O_2(g)$, dissolves in the Earth's oceans forming dissolved oxygen, $O_2(aq)$, which is essential for aquatic life.

An equilibrium is established.

$$O_2(g) + (aq) \rightleftharpoons O_2(aq) \qquad \Delta H = -12{\cdot}1\ kJ\ mol^{-1}$$

(*a*) (i) What is meant by a reaction at "equilibrium"?

1

(ii) What would happen to the concentration of dissolved oxygen if the temperature of the Earth's oceans increased?

1

(*b*) A sample of oceanic water was found to contain 0·010 g of dissolved oxygen.

Calculate the number of moles of dissolved oxygen present in the sample.

1

DO NOT WRITE IN THIS MARGIN

Marks

7. Hydrogen cyanide, HCN, is highly toxic.

(*a*) Information about hydrogen cyanide is given in the table.

Structure	H — C ≡ N
Molecular mass	27
Boiling point	26 °C

Although hydrogen cyanide has a similar molecular mass to nitrogen, it has a much higher boiling point. This is due to the permanent dipole–permanent dipole attractions in liquid hydrogen cyanide.

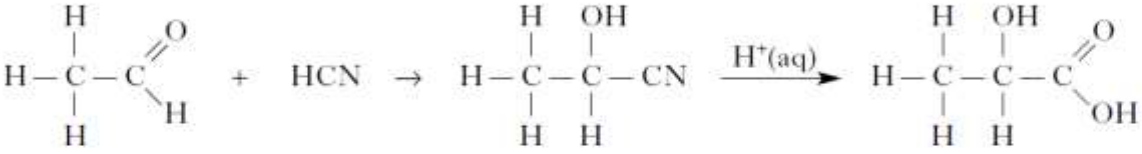
What is meant by permanent dipole–permanent dipole attractions?

Explain how they arise in liquid hydrogen cyanide.

2

(*b*) Hydrogen cyanide is of great importance in organic chemistry. It offers a route to increasing the chain length of a molecule.

If ethanal is reacted with hydrogen cyanide and the product hydrolysed with acid, lactic acid is formed.



ethanal lactic acid

Draw a structural formula for the acid produced when propanone is used instead of ethanal in the above reaction sequence.

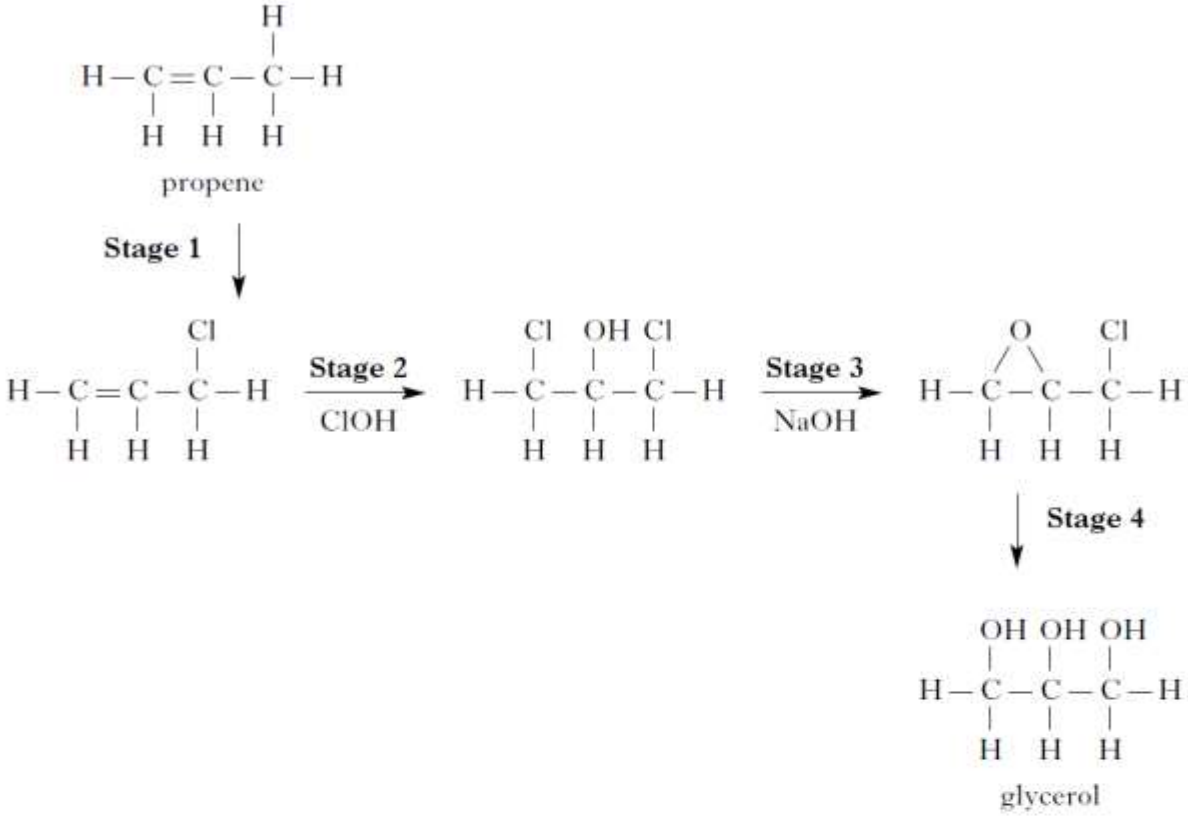
1

DO NOT WRITE IN THIS MARGIN

Marks

8. Glycerol, $C_3H_8O_3$, is widely used as an ingredient in toothpaste and cosmetics.

(*a*) Glycerol is mainly manufactured from fats and oils. Propene can be used as a feedstock in an alternative process as shown.



(i) What is meant by a feedstock?

1

(ii) Name the type of reaction taking place in **Stage 2**.

1

(iii) In **Stage 3**, a salt and water are produced as by-products.

Name the salt produced.

1

DO NOT WRITE IN THIS MARGIN

Marks

8. (*a*) (continued)

(iv) Apart from cost, state **one** advantage of using fats and oils rather than propene in the manufacture of glycerol.

1

(*b*) Hydrogen has been named as a 'fuel for the future'. In a recent article researchers reported success in making hydrogen from glycerol:

$$C_3H_8O_3(\ell) \rightarrow \quad CO_2(g) + \quad CH_4(g) + \quad H_2(g)$$

Balance this equation.

1

(*c*) The enthalpy of formation of glycerol is the enthalpy change for the reaction:

$$\underset{\text{(graphite)}}{3C(s)} + 4H_2(g) + 1\tfrac{1}{2}O_2(g) \rightarrow C_3H_8O_3(\ell)$$

Calculate the enthalpy of formation of glycerol, in kJ mol^{-1}, using information from the data booklet and the following data.

$$C_3H_8O_3(\ell) + 3\tfrac{1}{2}O_2(g) \rightarrow 3CO_2(g) + 4H_2O(\ell) \quad \Delta H = -1654\,kJ\ mol^{-1}$$

Show your working clearly.

2

DO NOT WRITE IN THIS MARGIN

Marks

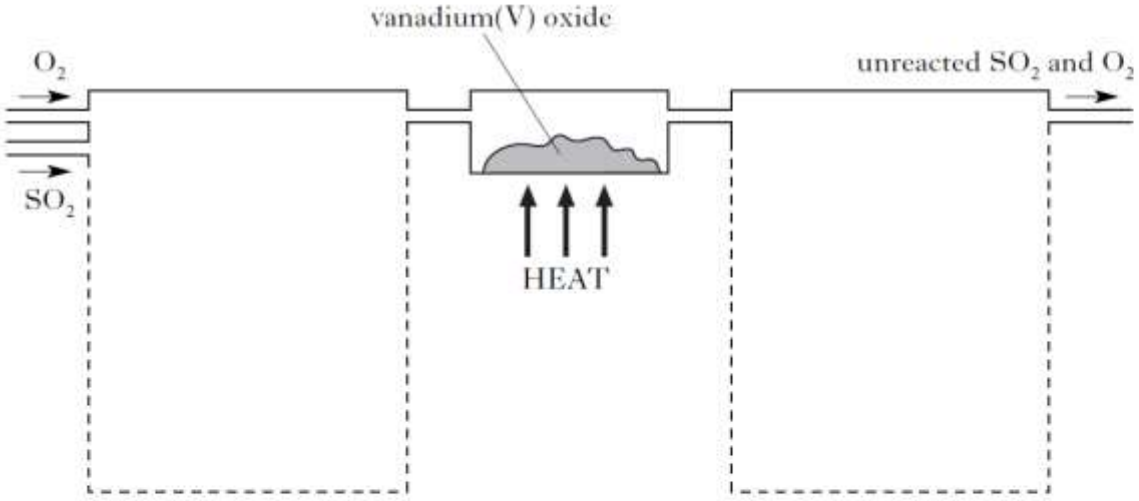
10. Sulphur trioxide can be prepared in the laboratory by the reaction of sulphur dioxide with oxygen.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

The sulphur dioxide and oxygen gases are dried by bubbling them through concentrated sulphuric acid. The reaction mixture is passed over heated vanadium(V) oxide.

Sulphur trioxide has a melting point of 17 °C. It is collected as a white crystalline solid.

(*a*) Complete the diagram to show how the reactant gases are dried and the product is collected.



2

(*b*) Under certain conditions, 43·2 tonnes of sulphur trioxide are produced in the reaction of 51·2 tonnes of sulphur dioxide with excess oxygen.

Calculate the percentage yield of sulphur trioxide.

Show your working clearly.

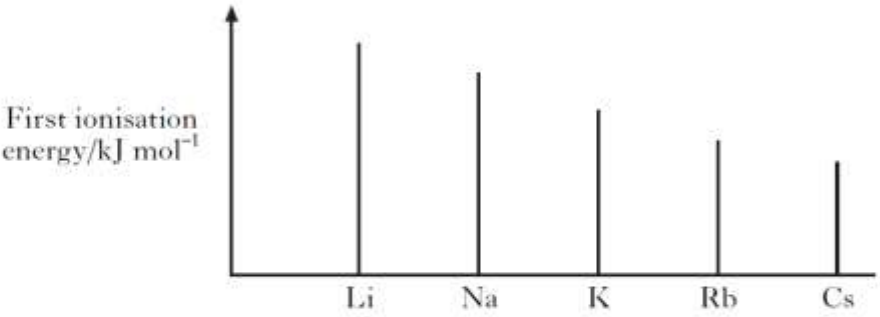
2

DO NOT WRITE IN THIS MARGIN

Marks

11. (*a*) The first ionisation energy of an element is defined as the energy required to remove one mole of electrons from one mole of atoms in the gaseous state.

The graph shows the first ionisation energies of the Group 1 elements.



(i) Clearly explain why the first ionisation energy decreases down this group.

2

(*b*) The ability of an atom to form a negative ion is measured by its Electron Affinity.

The Electron Affinity is defined as the energy change when one mole of gaseous atoms of an element combines with one mole of electrons to form gaseous negative ions.

Write the equation, showing state symbols, that represents the Electron Affinity of chlorine.

1

DO NOT WRITE IN THIS MARGIN

Marks

12. (*a*) A student bubbled 240 cm^3 of carbon dioxide into 400 cm^3 of 0·10 $moll^{-1}$ lithium hydroxide solution.

The equation for the reaction is:

$$2LiOH(aq) + CO_2(g) \rightarrow Li_2CO_3(aq) + H_2O(\ell)$$

Calculate the number of moles of lithium hydroxide that would **not** have reacted.

(Take the molar volume of carbon dioxide to be 24 litres mol^{-1}.)

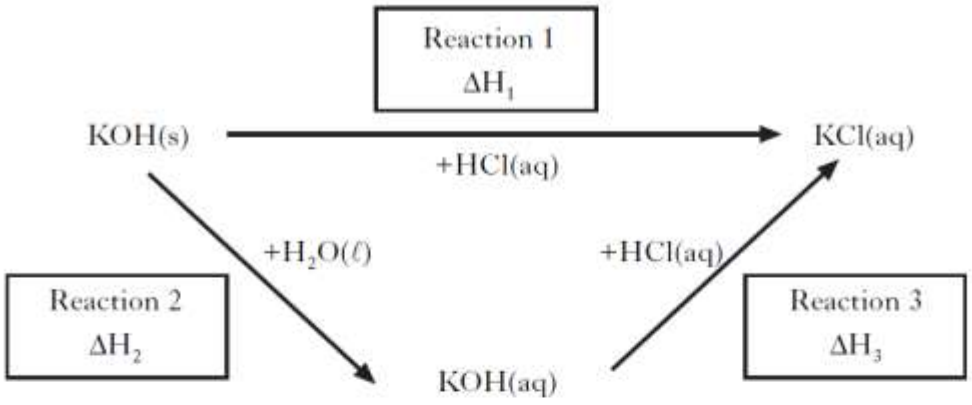
Show your working clearly.

2

DO NOT WRITE IN THIS MARGIN

Marks

14. (*a*) Hess's Law can be verified using the reactions summarised below.



(i) Complete the list of measurements that would have to be carried out in order to determine the enthalpy change for Reaction 2.

Reaction 2

1. Using a measuring cylinder, measure out 25 cm^3 of water into a polystyrene cup.

2.

3. Weigh out accurately about 1·2 g of potassium hydroxide and add it to the water, with stirring, until all the solid dissolves.

4.

1

(ii) Why was the reaction carried out in a polystyrene cup?

1

DO NOT WRITE IN THIS MARGIN

Marks

14. (*a*) (continued)

(iii) A student found that 1·08 kJ of energy was **released** when 1·2 g of potassium hydroxide was dissolved completely in water.

Calculate the enthalpy of solution of potassium hydroxide.

1

(*b*) A student wrote the following **incorrect** statement.

The enthalpy of neutralisation for hydrochloric acid reacting with potassium hydroxide is less than that for sulphuric acid reacting with potassium hydroxide because fewer moles of water are formed as shown in these equations.

$$HCl + KOH \rightarrow KCl + H_2O$$

$$H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$$

Explain the mistake in the student's statement.

1

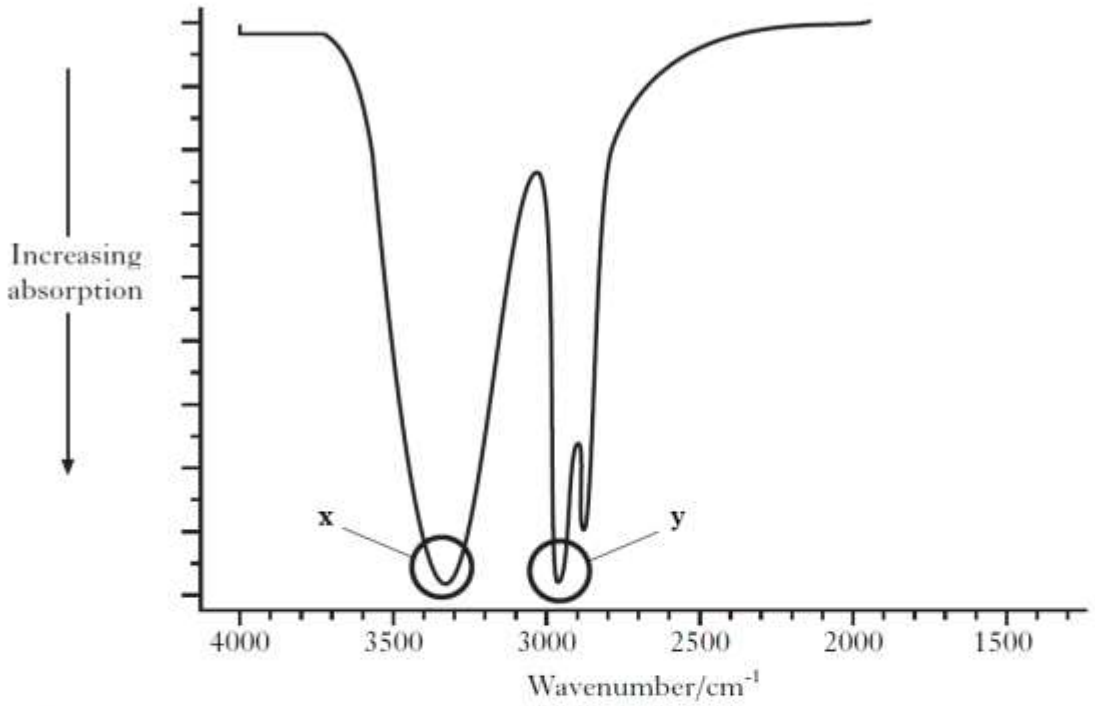
DO NOT WRITE IN THIS MARGIN

Marks

15. Infra-red spectroscopy is a technique that can be used to identify the bonds that are present in a molecule.

Different bonds absorb infra-red radiation of different wavenumbers. This is due to differences in the bond 'stretch'. These absorptions are recorded in a spectrum.

A spectrum for propan-1-ol is shown.



The correlation table on page 13 of the data booklet shows the wavenumber ranges for the absorptions due to different bonds.

(*a*) Use the correlation table to identify the bonds responsible for the two absorptions, **x** and **y**, that are circled in the propan-1-ol spectrum.

x: **y**:

1

(*b*) Propan-1-ol reacts with ethanoic acid.

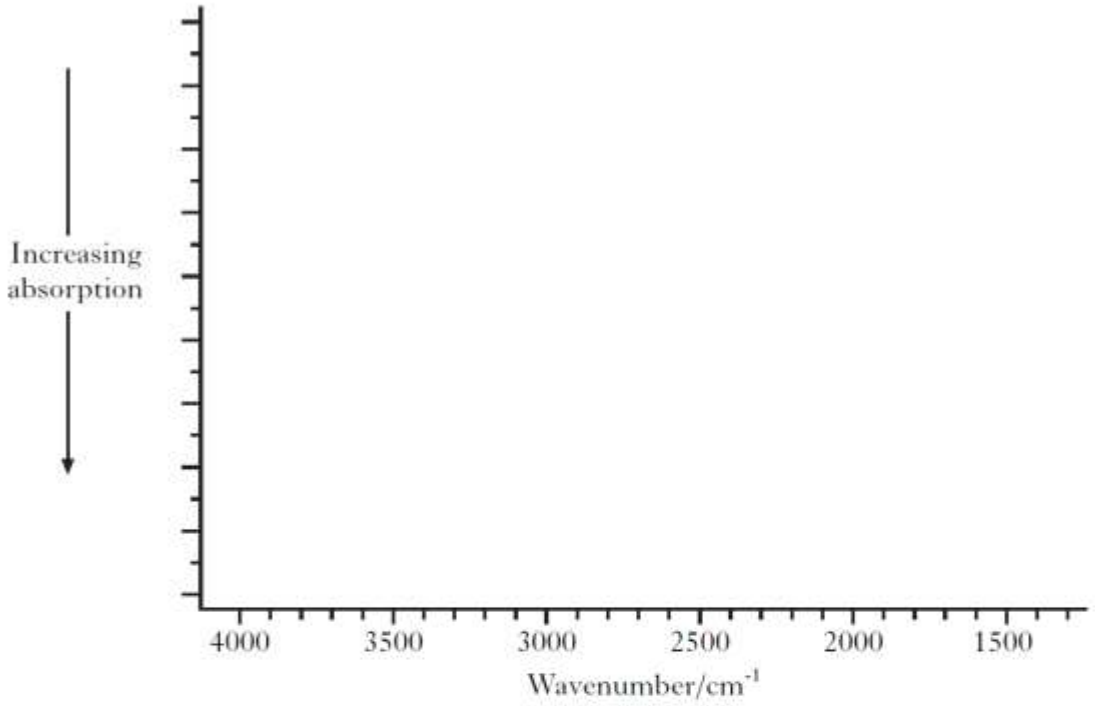
(i) What name is given to this type of reaction?

1

Marks

15. (*b*) (continued)

(ii) Draw a spectrum that could be obtained for the organic product of this reaction.



1

(3)

[Turn over

DO NOT WRITE IN THIS MARGIN

Marks

16. A major problem for the developed world is the pollution of rivers and streams by nitrite and nitrate ions.

The concentration of nitrite ions, $NO_2^-(aq)$, in water can be determined by titrating samples against acidified permanganate solution.

(*a*) Suggest **two** points of good practice that should be followed to ensure that an accurate end-point is achieved in a titration.

1

(*b*) An average of 21·6 cm^3 of 0·0150 mol l^{-1} acidified permanganate solution was required to react completely with the nitrite ions in a 25·0 cm^3 sample of river water.

The equation for the reaction taking place is:

$$2MnO_4^-(aq) + 5NO_2^-(aq) + 6H^+(aq) \rightarrow 2Mn^{2+}(aq) + 5NO_3^-(aq) + 3H_2O(\ell)$$

(i) Calculate the nitrite ion concentration, in mol l^{-1}, in the river water.

Show your working clearly.

2

(ii) During the reaction the nitrite ion is oxidised to the nitrate ion.

Complete the ion-electron equation for the oxidation of the nitrite ions.

$$NO_2^-(aq) \quad \rightarrow \quad NO_3^-(aq)$$

1

2010 Chemistry Higher

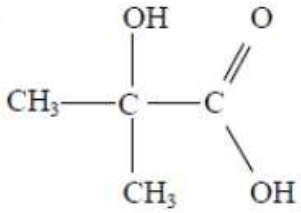
Marking Scheme

Section A

		11	B	21	C		
		12	A	22	C	32	A
		13	B			33	B
		14	D			34	C
5	B	15	D				
7	C						
8	B			28	C		
9	A	19	A	29	D		
10	D	20	B	30	D		

	Mark Scheme			Worth ½	Worth 0
1	lithium	metallic (or metal) (½)			
	boron	covalent (½)	network or lattice (½)		cross-linked or giant structure
	nitrogen	(discrete) molecular (or molecule) or diatomic (½)	2		discrete

		Mark Scheme		Worth ½	Worth 0
3	(a) (i)	rate of forward reaction equals rate of reverse reaction or concentration of reactants and products remain constant	1	forward reaction equals backward reaction or volume of products and reactants are constant	concentration of reactants and products are equal or volumes are equal or constant rate of reaction
	(ii)	decreases (or reduces or gets smaller or diminishes or lowers)	1	(equilibrium) shifts to left	
	(b)	no. of moles $= \frac{0.010}{32}$ (½) $= 3.125 \times 10^{-4} (0.00031)$ (½)	1	$\frac{0.010}{16} = 6.25 \times 10^{-4}$	

		Mark Scheme		Worth ½	Worth 0
7	**(a)**	intermolecular attractions (or forces) **or** attractions between molecules **(1)** any mention of a difference in electronegativity **(½)** carbon (or hydrogen) has a small positive charge and nitrogen a small negative charge **(½)** (accept diagram with key points, maximum **1½** marks if mention of hydrogen bonding)	**2**	mention of polar molecules (or positive and negative ends in a molecule)	attraction between atoms
	(b)	 	**1**		stage 1 product

Mark Scheme				Worth ½	Worth 0
8	(a)	(i)	a reactant from which other chemicals can be made (or synthesised or produced or obtained or derived) or product of one reaction becomes the reactant of another **1**		a raw material or starting material (or substance) or material (or substance) that can be used to make something else or a material (or substance) in the chemical industry
		(ii)	addition or additional **1**		
		(iii)	sodium chloride (accept correct formula) **1**		any incorrect formula
		(iv)	fats and oils are renewable (or will not run out or are unlimited) or propene is obtained from a finite source or reaction has fatty acids as bi-products **1**		fats and oils are widely available (or more common) or less polluting or less stages required to produce fats and oils or less energy required or useful bi-products, etc
	(b)		$2C_3H_8O_3 \rightarrow 3CO_2 + 3CH_4 + 2H_2$ **1** (accept multiples)		

Mark Scheme	Worth ½	Worth 0
(c) $3C + 3O_2 \rightarrow 3CO_2$ $-394 \times 3 = -1182$ kJ (½) $4H_2 + 2O_2 \rightarrow 4H_2O$ $-286 \times 4 = -1144$ kJ (½) $3CO_2 + 4H_2O \rightarrow C_3H_8O_3 + 7/2\,O_2 = +1654$ kJ (½) addition = -672 kJ mol^{-1} (½) **2** (3 'sensible' numbers required for ½ mark for addition based on following through; no units required; accept kJ; deduct ½ mark for incorrect units)		

	Mark Scheme	Worth ½	Worth 0
10 **(a)**	<u>for drying</u>, entry delivery tubes must be below surface of concentrated sulphuric acid and exit tube must be above **(1)** <u>for collection</u>, apparatus must be workable (½) and 'cooler' labelled (½) eg use of an ice/water bath **2**		
(b)	1 mol SO_2 → 1 mol SO_3 64.1g → 80.1g (½) 51.2 tonnes → $\frac{51.2 \times 80.1}{64.1} = 64.0$ tonnes (½) % yield = $\frac{\text{actual}}{\text{theoretical}} \times 100 = \frac{43.2}{64.0} \times 100$ (½) = 67.5% (½) **2** **or** moles of $SO_2 = \frac{51.2}{64.1} = 0.799$ (½) moles of $SO_3 = \frac{43.2}{80.1} = 0.539$ (½) % yield = $\frac{\text{actual}}{\text{theoretical}} \times 100 = \frac{0.539}{0.799} \times 100$ (½) = 67.5% (½)		$\frac{43.2 \times 100}{51.2} = 84.38$

Mark Scheme				Worth ½	Worth 0
11	**(a)**	**(i)**	outer electron is further away from the nucleus or greater number of electron shells **(1)** (increased) shielding (or screening) by the inner electrons or decreased nuclear attraction due to inner election shells **(1)** **2**	bigger atoms decreased nuclear attraction	
	(b)		$Cl(g) + e^- \rightarrow Cl^-(g)$ **1**		no state symbols

Mark Scheme			Worth ½	Worth 0
12	**(a)**	moles of LiOH = $0.1 \times 0.4 = 0.04$ **(½)** moles of $CO_2 = \frac{0.24}{24} = 0.01$ **(½)** 0.02 mol of LiOH reacts with 0.01 mol of CO_2 **(½)** excess LiOH = 0.02 **(½)** **2**		

Mark Scheme				Worth ½	Worth 0
14	**(a)**	**(i)**	2. measure the temperature (of the water) (½) 4. measure the highest temperature reached by the solution (½) **1**		measure final (or new) temperature or temperature of solution
		(ii)	to reduce (or prevent) heat loss to the surroundings or to keep heat in or less energy lost (or to conserve energy) **1**	polystyrene is an insulator	
		(iii)	1 mol KOH = 56.1 g 1.2 g ↔ 1.08 kJ 56.1 ↔ $\frac{1.08 \times 56.1}{1.2} = -50.49$ kJ mol^{-1} (½) **1** (accept kJ and (in this case) no units)	correct answer with incorrect or no sign and/or incorrect units	
	(b)		enthalpy change is for the formation of one mole of water or equivalent **1**	it's the same for both	two moles of water are formed with sulphuric acid

Mark Scheme				Worth ½	Worth 0
15	**(a)**	x is O-H (½) y is C-H (½)	**1**		
	(b)	**(i)** condensation or esterification	**1**		condensation polymerisation
		(ii) 2 peaks only: at 1705-1800 (½) and 2800-3000 (½) (deduct ½ mark for each additional incorrect peak)	**1**		

Mark Scheme			Worth ½	Worth 0
16	**(a)**	any 2 (½ mark each) from: flask should be swirled read burette at eye level white tile under flask add drop-wise (near end-point) no air bubble in burette **1** use an indicator to give a sharp colour change rinse with solutions being used titrate slowly remove funnel from burette put a piece of white paper behind burette stir constantly, etc.		rough titre, take average of readings, etc.
	(b)	**(i)** no. of moles of $MnO_4^-(aq) = 21.6 \times 1.50 \times 10^{-5} = 3.24 \times 10^{-4}$ **(½)** mole ratio 2:5 **(½)** no. of moles of $NO_2^- = 8.1 \times 10^{-4}$ **(½)** concentration = $\frac{8.1 \times 10^{-4}}{0.025} = 3.24 \times 10^{-2}$ **(½)** **2** (no units required; deduct ½ mark for incorrect units)	**Worth 1 mark** $\frac{3.24 \times 10^{-4}}{0.025} = 0.13$	
		(ii) $NO_2^-(aq) + H_2O(\ell) \rightarrow NO_3^-(aq) + 2H^+(aq) + 2e^-$ **1** (state symbols not required)		

[END OF MARKING INSTRUCTIONS]