SQA Higher Chemistry

Past Paper 2009

Marking Guide included at end of Paper.

2. In which of the following reactions is a positive ion reduced?

A Iodide ⟶ iodine

B Nickel(II) ⟶ nickel(III)

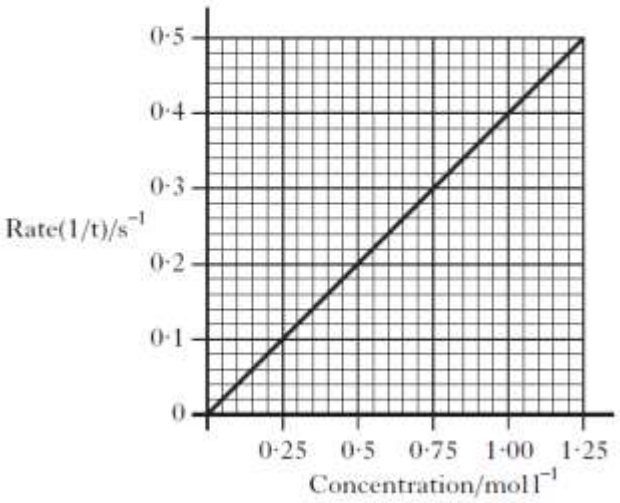
C Cobalt(III) ⟶ cobalt(II)

D Sulphate ⟶ sulphite

3. Which of the following elements is most likely to have a covalent network structure?

Element	Melting point/°C	Boiling point/°C	Density/ g cm^{-3}	Conduction when solid
A	44	280	1·82	No
B	660	2467	2·70	Yes
C	1410	2355	2·33	No
D	114	184	4·93	No

5. The graph shows how the rate of a reaction varies with the concentration of one of the reactants.



What was the reaction time, in seconds, when the concentration of the reactant was 0·50 mol l^{-1}?

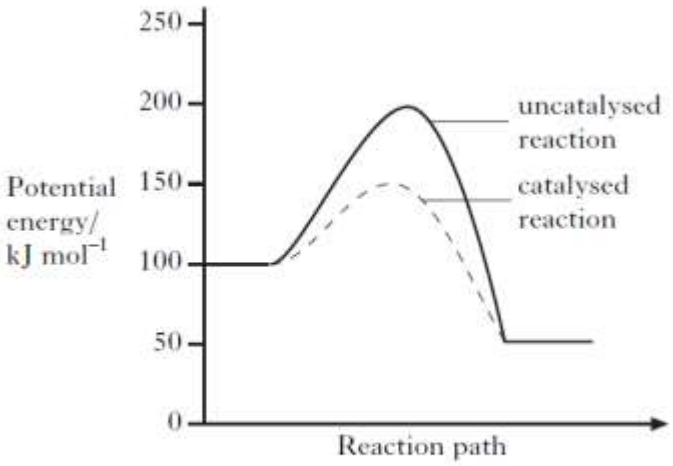
A 0·2

B 0·5

C 2·0

D 5·0

7. A reaction was carried out with and without a catalyst as shown in the energy diagram.



What is the enthalpy change, in kJ mol^{-1}, for the catalysed reaction?

A −100

B −50

C +50

D +100

8. Ethanol (C_2H_5OH) has a different enthalpy of combustion from dimethyl ether (CH_3OCH_3). This is because the compounds have different

A boiling points

B molecular masses

C products of combustion

D bonds within the molecules.

9. Which of the following compounds has the greatest ionic character?

A Caesium fluoride

B Caesium iodide

C Sodium fluoride

D Sodium iodide

10. Which line in the table is likely to be correct for the element francium?

	State at 30 °C	First ionisation energy/kJ mol^{-1}
A	solid	less than 382
B	liquid	less than 382
C	solid	greater than 382
D	liquid	greater than 382

11. Which of the following equations represents the first ionisation energy of fluorine?

A $F^-(g) \rightarrow F(g) + e^-$

B $F^-(g) \rightarrow \frac{1}{2}F_2(g) + e^-$

C $F(g) \rightarrow F^+(g) + e^-$

D $\frac{1}{2}F_2(g) \rightarrow F^+(g) + e^-$

12. The two hydrogen atoms in a molecule of hydrogen are held together by

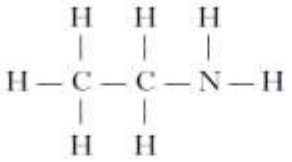
A a hydrogen bond

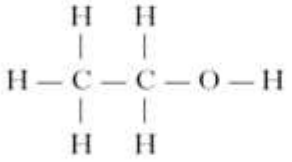
B a polar covalent bond

C a non-polar covalent bond

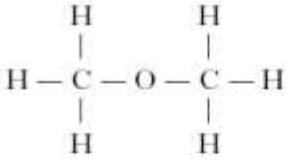
D a van der Waals' force.

13. In which of the following compounds would hydrogen bonding **not** occur?

A


B


C


D


15. What type of bonding and structure is found in a fullerene?

A Ionic lattice

B Metallic lattice

C Covalent network

D Covalent molecular

16. Some covalent compounds are made up of molecules that contain polar bonds but the molecules are overall non-polar.

Which of the following covalent compounds is made up of non-polar molecules?

A Ammonia

B Water

C Carbon tetrachloride

D Hydrogen fluoride

18. Which of the following gas samples has the same volume as 7 g of carbon monoxide?

(All volumes are measured at the same temperature and pressure.)

A 1 g of hydrogen

B 3·5 g of nitrogen

C 10 g of argon

D 35·5 g of chlorine

19. What volume of oxygen (in litres) would be required for the complete combustion of a gaseous mixture containing 1 litre of carbon monoxide and 3 litres of hydrogen?

(All volumes are measured at the same temperature and pressure.)

A 1

B 2

C 3

D 4

21. Which of the following compounds does **not** have isomeric structures?

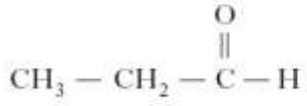
A C_2HCl_3

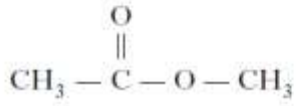
B $C_2H_4Cl_2$

C Propene

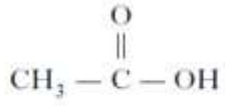
D Propan-1-ol

22. Which of the following compounds is an alkanone?

A 

B 

C 

D 

23. What organic compound is produced by the dehydration of ethanol?

A Ethane

B Ethene

C Ethanal

D Ethanoic acid

25. Compound **X** reacted with hot copper(II) oxide and the organic product did not give a colour change when heated with Fehling's solution.

Compound **X** could be

A butan-1-ol

B butan-2-ol

C butanone

D butanoic acid.

28. Which of the following reactions takes place during the 'hardening' of vegetable oil?

A Addition

B Hydrolysis

C Dehydration

D Oxidation

32.

$$S(s) + H_2(g) \rightarrow H_2S(g) \quad \Delta H = a$$

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(\ell) \quad \Delta H = b$$

$$S(s) + O_2(g) \rightarrow SO_2(g) \quad \Delta H = c$$

$$H_2S(g) + 1\tfrac{1}{2}O_2(g) \rightarrow H_2O(\ell) + SO_2(g) \quad \Delta H = d$$

What is the relationship between a, b, c and d?

A $a = b + c - d$

B $a = d - b - c$

C $a = b - c - d$

D $a = d + c - b$

33. A catalyst is added to a reaction at equilibrium.

Which of the following does **not** apply?

A The rate of the forward reaction increases.

B The rate of the reverse reaction increases.

C The position of equilibrium remains unchanged.

D The position of equilibrium shifts to the right.

37. Iodide ions can be oxidised using acidified potassium permanganate solution.

The equations are:

$$2I^-(aq) \rightarrow I_2(aq) + 2e^-$$

$$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(\ell)$$

How many moles of iodide ions are oxidised by one mole of permanganate ions?

A 1·0

B 2·0

C 2·5

D 5·0

Marks

SECTION B

All answers must be written clearly and legibly in ink.

1. (*a*) Lithium starts the second period of the Periodic Table.

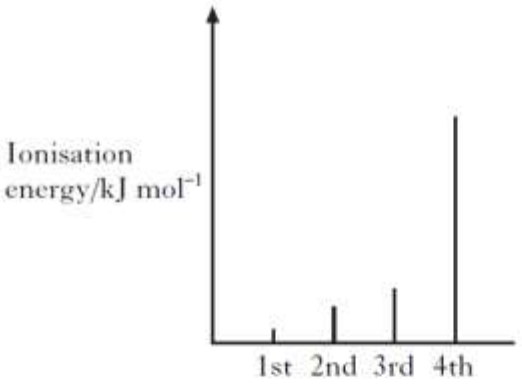
Li	Be	B	C	N	O	F

What is the trend in electronegativity values across this period from Li to F?

1

(*b*) **Graph 1** shows the first four ionisation energies for aluminium.

Graph 1

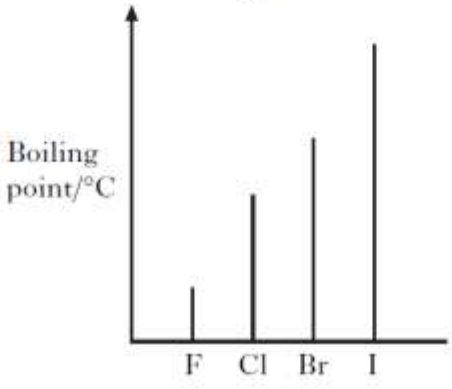


Why is the fourth ionisation energy of aluminium so much higher than the third ionisation energy?

1

(*c*) **Graph 2** shows the boiling points of the elements in Group 7 of the Periodic Table.

Graph 2



Why do the boiling points increase down Group 7?

1

DO NOT WRITE IN THIS MARGIN

Marks

3. Alkanols can be oxidised to alkanoic acids.

$CH_3CH_2CH_2OH$ **Step 1** CH_3CH_2CHO **Step 2** CH_3CH_2COOH

propan-1-ol propanal propanoic acid

(*a*) (i) Why can **Step 1** be described as an oxidation reaction?

1

(ii) Acidified potassium dichromate solution can be used to oxidise propanal in **Step 2**.

What colour change would be observed in this reaction?

1

(*b*) Propan-1-ol and propanoic acid react to form an ester.

The mixture of excess reactants and ester product is poured onto sodium hydrogencarbonate solution.

(i) What evidence would show that an ester is formed?

1

(ii) Draw a structural formula for this ester.

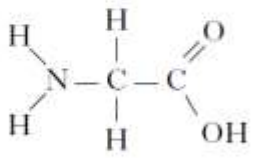
1

DO NOT WRITE IN THIS MARGIN

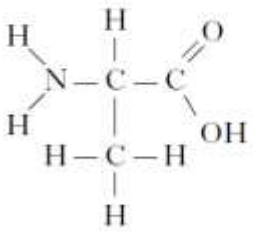
Marks

5. Polymers can be classified as natural or synthetic.

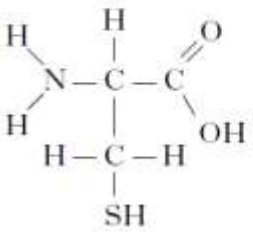
(*a*) Keratin, a natural polymer, is a protein found in hair.
The hydrolysis of keratin produces different monomers of the type shown.



glycine



alanine



cysteine

(i) What name is given to monomers like glycine, alanine and cysteine?

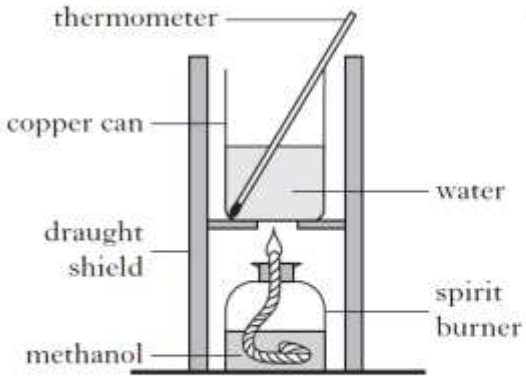
1

(ii) What is meant by a **hydrolysis** reaction?

1

Marks

6. A student used the simple laboratory apparatus shown to determine the enthalpy of combustion of methanol.



(*a*) (i) What measurements are needed to calculate the energy released by the burning methanol?

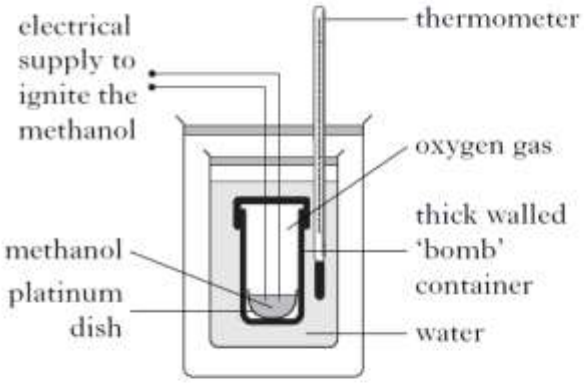
1

(ii) The student found that burning 0·370 g of methanol produces 3·86 kJ of energy.

Use this result to calculate the enthalpy of combustion of methanol.

1

(*b*) A more accurate value can be obtained using a bomb calorimeter.



One reason for the more accurate value is that less heat is lost to the surroundings than in the simple laboratory method.

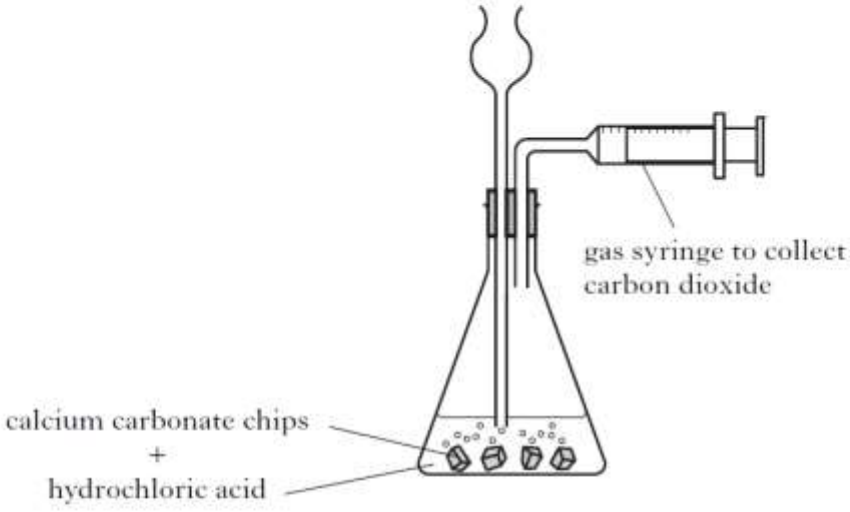
Give **one** other reason for the value being more accurate in the bomb calorimeter method.

1

DO NOT WRITE IN THIS MARGIN

Marks

7. An experiment was carried out to determine the rate of the reaction between hydrochloric acid and calcium carbonate chips. The rate of this reaction was followed by measuring the volume of gas released over a certain time.



(*a*) Describe a different way of measuring volume in order to follow the rate of this reaction.

1

(*b*) What other variable could be measured to follow the rate of this reaction?

1

8. Ammonia is produced in industry by the Haber Process.

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

(*c*) Under certain conditions, 500 kg of nitrogen reacts with excess hydrogen to produce 405 kg of ammonia.

Calculate the percentage yield of ammonia under these conditions.

Show your working clearly.

2

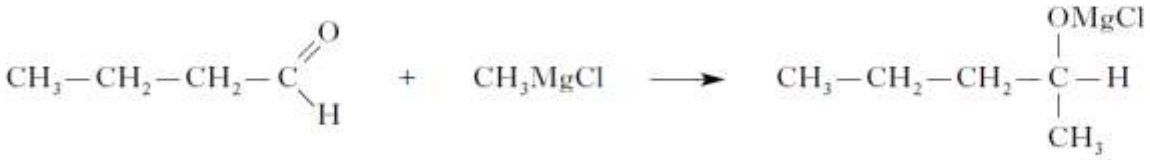
DO NOT WRITE IN THIS MARGIN

Marks

9. Primary, secondary and tertiary alkanols can be prepared by the reaction of carbonyl compounds with Grignard reagents.

Step 1

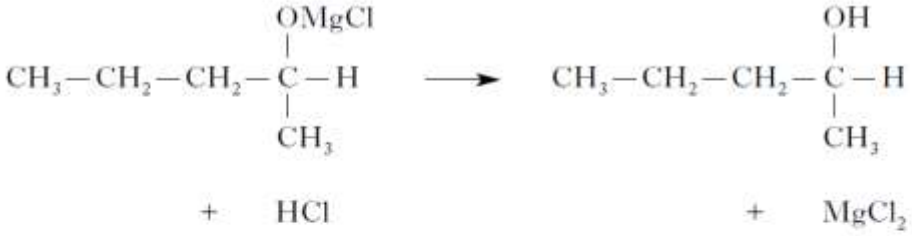
The Grignard reagent reacts with the carbonyl compound.



butanal Grignard reagent

Step 2

The reaction of the product of **Step 1** with dilute acid produces the alkanol.



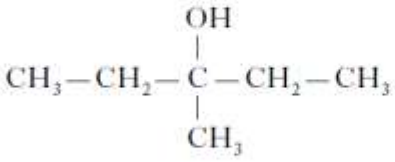
(*a*) Describe the difference between a primary, a secondary and a tertiary alkanol. You may wish to include labelled structures in your answer.

1

(*b*) Suggest a name for the type of reaction that takes place in **Step 1**.

1

(*c*) The same Grignard reagent can be used to produce the alkanol below.



Name the carbonyl compound used in this reaction.

1

DO NOT WRITE IN THIS MARGIN

Marks

10. Sherbet contains a mixture of sodium hydrogencarbonate and tartaric acid. The fizzing sensation in the mouth is due to the carbon dioxide produced in the following reaction.

$$2NaHCO_3 + C_4H_6O_6 \rightarrow Na_2(C_4H_4O_6) + 2H_2O + 2CO_2$$

sodium hydrogencarbonate — tartaric acid — sodium tartrate

(*a*) Name the type of reaction taking place.

1

(*b*) The chemical name for tartaric acid is 2,3-dihydroxybutanedioic acid.

Draw a structural formula for tartaric acid.

1

(*c*) In an experiment, a student found that adding water to 20 sherbet sweets produced 105 cm^3 of carbon dioxide.

Assuming that sodium hydrogencarbonate is in excess, calculate the average mass of tartaric acid, in grams, in one sweet.

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

Show your working clearly.

2

DO NOT WRITE IN THIS MARGIN

Marks

11. The following answers were taken from a student's examination paper.

The two answers are incorrect.

For each question, give the correct explanation.

(*a*) **Question** As a rough guide, the rate of a reaction tends to double for every 10 °C rise in temperature.

Why does a small increase in temperature produce a large increase in reaction rate?

Student answer Because rising temperature increases the activation energy which increases the number of collisions which speeds up the reaction greatly.

Correct explanation

1

(*b*) **Question** Explain the difference in atomic size between potassium and chlorine atoms.

Student answer A potassium nucleus has 19 protons but a chlorine nucleus has only 17 protons. The greater pull on the outer electron in the potassium atom means the atomic size of potassium is less than that of chlorine.

Correct explanation

1

DO NOT WRITE IN THIS MARGIN

Marks

15. (*a*) Methane is produced in the reaction of aluminium carbide with water.

$$Al_4C_3 \quad + \quad H_2O \quad \rightarrow \quad Al(OH)_3 \quad + \quad CH_4$$

Balance the above equation.

1

(*b*) Silane, silicon hydride, is formed in the reaction of silicon with hydrogen.

$$Si(s) \quad + \quad 2H_2(g) \quad \rightarrow \quad \underset{\text{silane}}{SiH_4(g)}$$

The enthalpy change for this reaction is called the enthalpy of formation of silane.

The combustion of silane gives silicon dioxide and water.

$SiH_4(g) \quad + \quad 2O_2(g) \quad \rightarrow \quad SiO_2(s) \quad + \quad 2H_2O(\ell) \quad \Delta H = -1517\,kJ\ mol^{-1}$

The enthalpy of combustion of silicon is $-911\,kJ\ mol^{-1}$.

Use this information and the enthalpy of combustion of hydrogen in the data booklet to calculate the enthalpy of formation of silane, in $kJ\ mol^{-1}$.

Show your working clearly.

2

DO NOT WRITE IN THIS MARGIN

Marks

17. Carbon-13 NMR is a technique used in chemistry to determine the structure of organic compounds.

(*a*) Calculate the neutron to proton ratio in an atom of carbon-13.

1

(*b*) The technique allows a carbon atom in a molecule to be identified by its 'chemical shift'. This value depends on the other atoms bonded to the carbon atom.

Shift table

Carbon environment	Chemical shift/ppm
C = O (in ketones)	205 – 220
C = O (in aldehydes)	190 – 205
C = O (in acids and esters)	170 – 185
C = **C** (in alkenes)	115 – 140
C ≡ **C** (in alkynes)	70 – 95
−**C**H	25 – 50
−**C**H_2	16 – 40
−**C**H_3	5 – 15

In a carbon-13 NMR spectrum, the number of lines correspond to the number of chemically different carbon atoms and the position of the line (the value of the chemical shift) indicates the type of carbon atom.

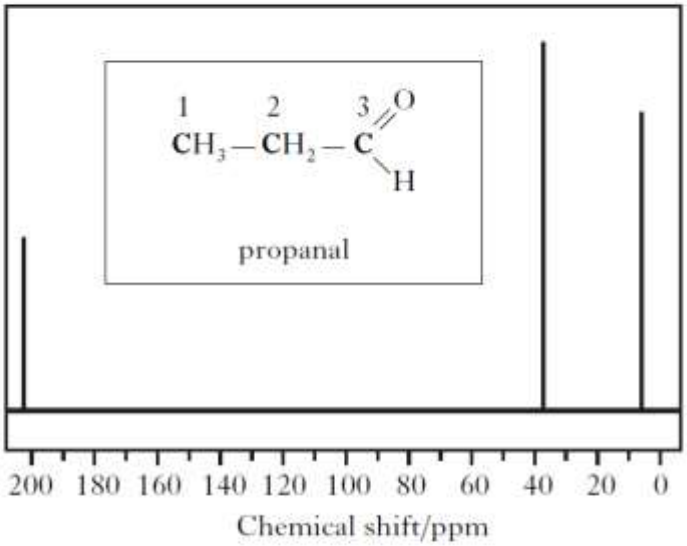
DO NOT WRITE IN THIS MARGIN

Marks

17. (*b*) (continued)

The spectrum for propanal is shown.

Spectrum 1

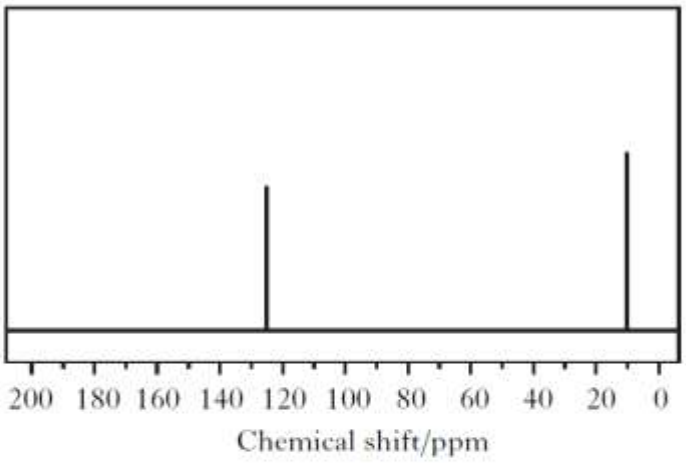


(i) Use the table of chemical shifts to label each of the peaks on the spectrum with a number to match the carbon atom in propanal that is responsible for the peak. **1**

(ii) Hydrocarbon **X** has a relative formula mass of 54. Hydrocarbon **X** reacts with hydrogen. One of the products, hydrocarbon **Y**, has a relative formula mass of 56.

The carbon-13 NMR spectrum for hydrocarbon **Y** is shown below.

Spectrum 2



Name hydrocarbon **Y**. **1**

DO NOT WRITE IN THIS MARGIN

Marks

18. The number of moles of carbon monoxide in a sample of air can be measured as follows.

Step 1 The carbon monoxide reacts with iodine(V) oxide, producing iodine.

$$5CO(g) + I_2O_5(s) \rightarrow I_2(s) + 5CO_2(g)$$

Step 2 The iodine is then dissolved in potassium iodide solution and titrated against sodium thiosulphate solution.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$$

(*a*) Write the ion-electron equation for the oxidation reaction in **Step 2**.

1

(*b*) Name a chemical that can be used to indicate when all of the iodine has been removed in the reaction taking place in **Step 2**.

1

(*c*) If 50·4 cm^3 of 0·10 $mol\,l^{-1}$ sodium thiosulphate solution was used in a titration, calculate the number of moles of carbon monoxide in the sample of air.

Show your working clearly.

2

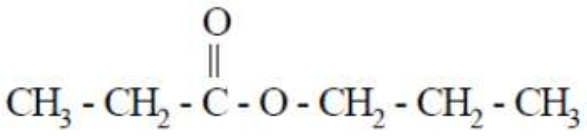
2009 Chemistry Higher

Marking Scheme

Section A

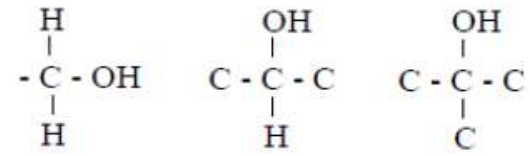
		11	C	21	A		
2	C	12	C	22	C	32	A
3	C	13	D	23	B	33	D
5	D	15	D	25	B		
		16	C				
7	B					37	D
8	D	18	C	28	A		
9	A	19	B				
10	B						

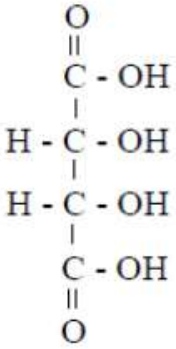
		Mark Scheme		Worth ½	Worth 0
1	(a)	increases (or gets bigger or rises)	1		
	(b)	more energy is needed to remove the electron from a full shell (or complete shell or noble gas shell) **or** an electron is being removed from an energy level closer to the nucleus **or** there is a greater nuclear pull on the electron being removed **or** second energy level is nearer the nucleus **or** second energy level is full (or complete), etc.	1		
	(c)	forces of attraction **between** molecules (or intermolecular forces or van der Waals' forces) increase **or** energy needed to separate the molecules increases.	1	molecular size increases **or** iodine molecules (or atoms) are bigger then fluorine	bonding is stronger in iodine than fluorine **or** any mention of stronger covalent bonds

			Mark Scheme		Worth ½	Worth 0
3	(a)	(i)	ratio of oxygen:hydrogen atoms increased (or ratio of hydrogen:oxygen atoms decreased) **or** removal of hydrogen	1	removal of hydrogen molecules	loss of electrons
		(ii)	orange to green (or blue/green)	1	goes green (or blue/green) **or** orange colour is lost	orange to incorrect colour (or colourless) **or** incorrect colour (or colourless) to green
	(b)	(i)	Any mention of separate layer **or** any mention of (ester) smell	1		
		(ii)	 (accept equivalent full **or** shortened structural formula)	1		

			Mark Scheme		Worth ½	Worth 0
5	(a)	(i)	amino acids	1		
		(ii)	breaking up (bonds in) a molecule by the addition of (the elements from) water	1		breaking up (bonds in) a molecule **or** addition of water **or** reverse of condensation

		Mark Scheme		Worth ½	Worth 0
7	**(a)**	use an (upturned) measuring cylinder (or graduated tube) filled with water **or** collect gas over water **or** correct diagram	**1**	as for 1 mark but use of a non-graduated tube **or** count the number of bubbles produced under water	use a measuring cylinder (or graduated tube)
	(b)	mass (or weight) **or** pH **or** concentration of acid **or** conductivity	**1**		
8	**(c)**	$1 \text{ mol } N_2 \rightarrow 2 \text{ mol } NH_3$ $28 \text{ g} \rightarrow 34 \text{ g}$ **(½)** $500 \text{ kg} \rightarrow \frac{500 \times 28}{34} = 607 \text{ kg}$ **(½)** $\%\text{ yield} = \frac{\text{actual}}{\text{theoretical}} \times 100 = \frac{405}{607} \times 100$ **(½)** $= 66.7\%$ **(½)** **or** $\text{no. of moles of } N_2 = \frac{500\,000}{28} = 17\,860 \text{ mol}$ $\text{no. of moles of } NH_3 = 35\,720 \text{ mol}$ **(½)** $= 607 \text{ kg}$ **(½)**	**2**		

		Mark Scheme		Worth ½	Worth 0
9	(a)	 primary secondary tertiary **or** Primary: hydroxyl group attached to C attached to two H atoms (or hydroxyl group attached to C attached to one C atom) Secondary: hydroxyl group attached to C attached to one H atom (or hydroxyl group attached to C attached to two C atoms) Tertiary: hydroxyl group attached to C attached to no H atoms (or hydroxyl group attached to C attached to three C atoms) **or** correct answer in terms of oxidation	**1**	2 out of 3 correct	
	(b)	addition	**1**		
	(c)	pentan-3-one	**1**	pentanone **or** pentan-2-one	pentone **or** pentan-1-one

Mark Scheme			Worth ½	Worth 0
10	**(a)**	neutralisation **1**		titration
	(b)	 (accept equivalent full or shortened structural formula) **1**		
	(c)	1 mol $C_4H_6O_6$ → 2 mol CO_2 = 48 l (½) 150 g (½) → 48 l $\frac{150 \times 0.105}{48}$ g → 0.105 l = 0.33 g (½) mass in 1 sweet = 0.0165 g (½) **or** no. of moles of CO_2 = $\frac{0.105}{24}$ = 0.0044 mol (½) no. of moles of $C_4H_6O_6$ = 0.0022 mol (½) = 0.0022 × 150 = 0.33 g (½) mass in 1 sweet = 0.0165 g (½) (no units required; deduct ½ mark for incorrect units) **2**		

		Mark Scheme		Worth ½	Worth 0
11	(a)	more collisions with energy greater or equal to E_a **or** more collisions leading to an activated complex **or** correct energy distribution diagram	1	more successful collisions	just increases the number of collisions
	(b)	the outer electron in potassium is further from the nucleus **or** the outer electron is in a higher (or the fourth) energy level **(½) or** the inner shells screen (or shield) the outer electron from the (pull of the) nucleus **(½) or** corresponding explanation based on chlorine	1		

		Mark Scheme		Worth ½	Worth 0
15	(a)	$Al_4C_3 + 12H_2O \rightarrow 4Al(OH)_3 + 3CH_4$	1		
	(b)	$SiO_2(s) + 2H_2O(\ell) \rightarrow SiH_4(g) + 2O_2(g)$ +1517 kJ **(½)** $Si(s) + O_2(g) \rightarrow SiO_2(s)$ - 911 kJ **(½)** $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$ - 572 kJ **(½)** addition = 34 kJ mol^{-1} **(½)** (3 'sensible' numbers required for ½ mark for addition based on following through; no units required; deduct ½ mark for incorrect units)	2		

Mark Scheme				Worth ½	Worth 0
17	**(a)**	1.17 (or 7:6)	**1**	p:n = 6:7	
	(b)	**(i)** left to right 3, 2, 1	**1**		
		(ii) but-2-ene	**1**	butene **or** butan-2-ene	

		Mark Scheme		Worth ½	Worth 0
18	(a)	$2S_2O_3^{2-}(aq) \rightarrow S_4O_6^{2-}(aq) + 2e^-$ (state symbols not required)	1		
	(b)	starch (solution)	1		
	(c)	no. of moles of $S_2O_3^{2-}(aq) = 0.0504 \times 0.10 = 0.00504$ (½) mole ratio 2:5 **(1)** no. of moles of CO = 0.0125 (½) **or** no. of moles of $S_2O_3^{2-}(aq) = 0.504 \times 0.10 = 0.00504$ (½) moles of iodine : thiosulphate is 1:2 moles of iodine = 0.0025 (½) moles of CO : iodine is 5:1 (½) moles of CO = 0.0125 (½)	2		

[END OF MARKING INSTRUCTIONS]