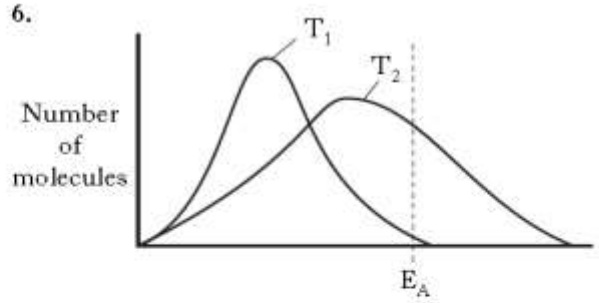
SQA Higher Chemistry

Past Paper 2011

Edited for CfE Higher

Marking guide included at end of paper.

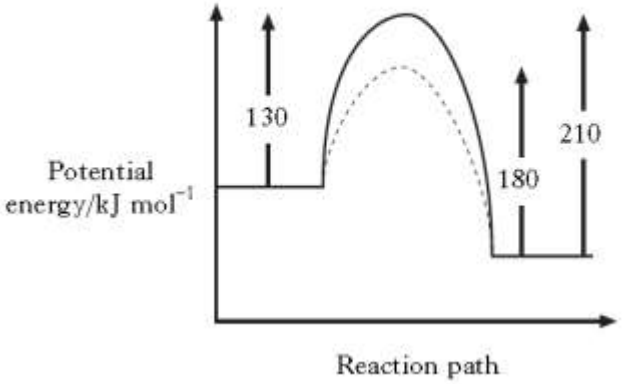
6.



Which line in the table is correct for a reaction as the temperature **decreases** from T_2 to T_1?

	Activation energy (E_A)	**Number of successful collisions**
A	remains the same	increases
B	decreases	decreases
C	decreases	increases
D	remains the same	decreases

9. The following potential diagram is for a reaction carried out with and without a catalyst.



The activation energy for the catalysed reaction is

A $30\,kJ\,mol^{-1}$

B $80\,kJ\,mol^{-1}$

C $100\,kJ\,mol^{-1}$

D $130\,kJ\,mol^{-1}$.

10. Which of the following equations represents an enthalpy of combustion?

A $C_2H_6(g) + 3\frac{1}{2}O_2(g) \rightarrow 2CO_2(g) + 3H_2O(\ell)$

B $C_2H_5OH(\ell) + O_2(g) \rightarrow CH_3COOH(\ell) + H_2O(\ell)$

C $CH_3CHO(\ell) + \frac{1}{2}O_2(g) \rightarrow CH_3COOH(\ell)$

D $CH_4(g) + 1\frac{1}{2}O_2(g) \rightarrow CO(g) + 2H_2O(\ell)$

11. A potassium atom is larger than a sodium atom because potassium has

A a larger nuclear charge

B a larger nucleus

C more occupied energy levels

D a smaller ionisation energy.

13. Which property of a chloride would prove that it contained ionic bonding?

A It conducts electricity when molten.

B It is soluble in a polar solvent.

C It is a solid at room temperature.

D It has a high boiling point.

15. Which of the following has the largest volume under the same conditions of temperature and pressure?

A 1 g hydrogen

B 14 g nitrogen

C 20·2 g neon

D 35·5 g chlorine

19. Which of the following hydrocarbons always gives the same product when one of its hydrogen atoms is replaced by a chlorine atom?

A Hexane

B Hex-1-ene

C Cyclohexane

D Cyclohexene

20.

The name of this compound is

A methanol

B methanal

C methanoic acid

D methanone.

21. Which of the following is an isomer of ethyl propanoate?

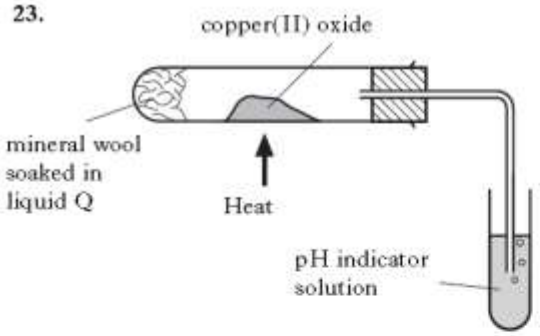
A Pentan-2-one

B Pentanoic acid

C Methyl propanoate

D Pentane-1,2-diol

23.



After heating for several minutes, as shown in the diagram, the pH indicator solution turned red.

Liquid Q could be

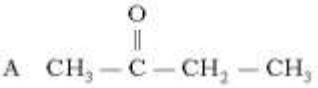
A propanone

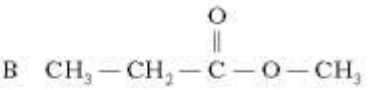
B paraffin

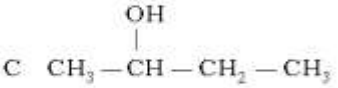
C propan-1-ol

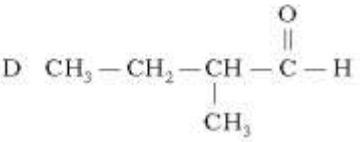
D propan-2-ol.

24. Which of the following compounds is hydrolysed when warmed with sodium hydroxide solution?

A 

B 

C 

D 

25. Which of the following is most likely to be used as a flavouring?

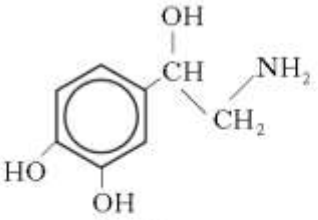
A CH_3CH_2CHO

B $CH_3CH_2CH_2COOH$

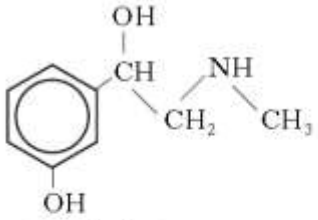
C $CH_3CH(OH)CH_2CH_3$

D $CH_3CH_2CH_2COOCH_2CH_3$

28. Noradrenaline and phenylephrine cause increases in the blood pressure because the part of each of these molecules that they have in common has the correct shape to allow them to bind to a certain human protein.



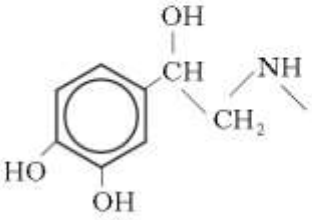
noradrenaline



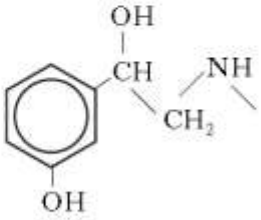
phenylephrine

The part of these molecules which is the correct shape to bind to the protein is

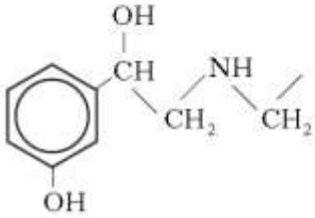
A



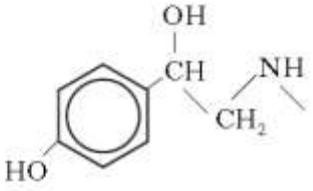
B



C



D



32. The enthalpy change for $K(s) \rightarrow K(g)$ is $88\,kJ\,mol^{-1}$.

Using the above information and information from the data booklet (page 10), the enthalpy change for $K(s) \rightarrow K^{2+}(g) + 2e^-$ is

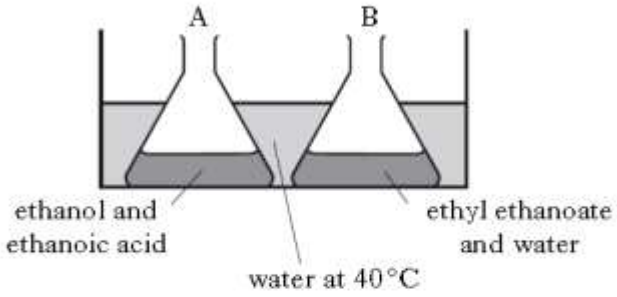
A $513\,kJ\,mol^{-1}$

B $3060\,kJ\,mol^{-1}$

C $3485\,kJ\,mol^{-1}$

D $3573\,kJ\,mol^{-1}$.

33. Two flasks, A and B, were placed in a water bath at 40 °C.



After several days the contents of both flasks were analysed.

Which result would be expected?

A Flask A contains ethyl ethanoate, water, ethanol and ethanoic acid; flask B is unchanged.

B Flask A contains only ethyl ethanoate and water; flask B is unchanged.

C Flask A contains only ethyl ethanoate and water; flask B contains ethyl ethanoate, water, ethanol and ethanoic acid.

D Flask A and flask B contain ethyl ethanoate, water, ethanol and ethanoic acid.

34. $NH_3(g) + H_2O(\ell) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$

$\Delta H = -36\,kJ\ mol^{-1}$

The solubility of ammonia in water will be increased by

A increasing pressure and cooling

B decreasing pressure and cooling

C decreasing pressure and warming

D increasing pressure and warming.

37. During a redox process in acid solution, iodate ions are converted into iodine.

$2IO_3^-(aq) + 12H^+(aq) + \mathbf{x}e^- \rightarrow I_2(aq) + 6H_2O(\ell)$

To balance the equation, what is the value of **x**?

A 2

B 6

C 10

D 12

SECTION B

Marks

All answers must be written clearly and legibly in ink.

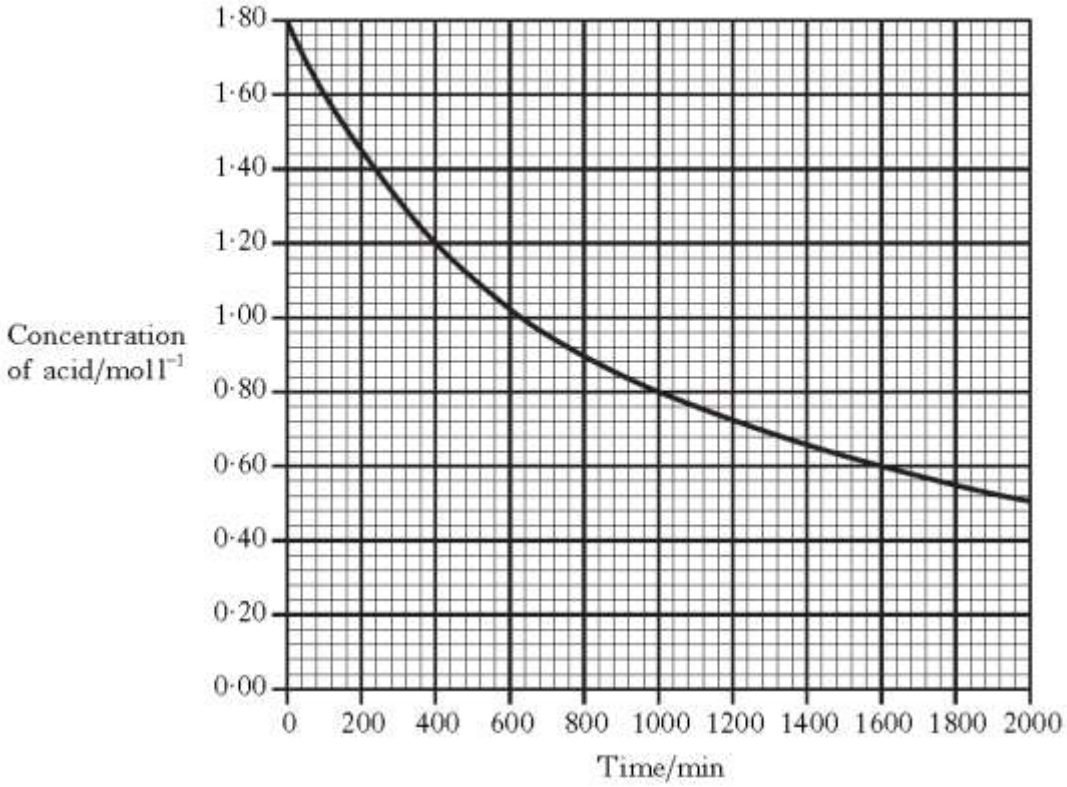
1. Chloromethane, CH_3Cl, can be produced by reacting methanol solution with dilute hydrochloric acid using a solution of zinc chloride as a catalyst.

$$CH_3OH(aq) + HCl(aq) \xrightarrow{ZnCl_2(aq)} CH_3Cl(aq) + H_2O(\ell)$$

(*a*) What type of catalysis is taking place?

1

(*b*) The graph shows how the concentration of the hydrochloric acid changed over a period of time when the reaction was carried out at 20 °C.



(i) Calculate the average rate, in mol l^{-1} min^{-1}, in the first 400 minutes.

1

(ii) On the graph above, sketch a curve to show how the concentration of hydrochloric acid would change over time if the reaction is repeated at 30 °C.
(Additional graph paper, if required, can be found on *Page thirty-five*).

1

DO NOT WRITE IN THIS MARGIN

Marks

2. The elements from sodium to argon make up the third period of the Periodic Table.

(*a*) On crossing the third period from left to right there is a general increase in the first ionisation energy of the elements.

(i) Why does the first ionisation energy increase across the period?

1

(ii) Write an equation corresponding to the first ionisation energy of chlorine.

1

(*b*) The electronegativities of elements in the third period are listed on page 10 of the databook.

Why is no value provided for the noble gas, argon?

1

DO NOT WRITE IN THIS MARGIN

Marks

3. A student writes the following two statements. **Both are incorrect**. In each case explain the mistake in the student's reasoning.

(*a*) All ionic compounds are solids at room temperature. Many covalent compounds are gases at room temperature. This proves that ionic bonds are stronger than covalent bonds.

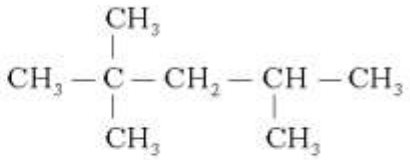
1

(*b*) The formula for magnesium chloride is $MgCl_2$ because, in solid magnesium chloride, each magnesium ion is bonded to two chloride ions.

1

4. Petrol is a complex blend of many chemicals.

(*a*) A typical hydrocarbon found in petrol is shown below.



What is the systematic name for this compound?

1

(*c*) The ester methyl stearate is also a useful vehicle fuel.

A student prepared this ester from methanol and stearic acid during the Prescribed Practical Activity, "Making Esters".

Describe how this ester was prepared.

2

5. Chlorine gas can be produced by heating calcium hypochlorite, $Ca(OCl)_2$, in dilute hydrochloric acid.

$$Ca(OCl)_2(s) + 2HCl(aq) \rightarrow Ca(OH)_2(aq) + 2Cl_2(g)$$

(*a*) Calculate the mass of calcium hypochlorite that would be needed to produce 0·096 litres of chlorine gas.

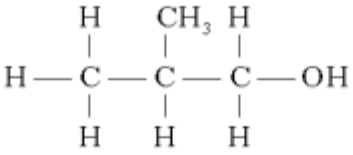
(Take the molar volume of chlorine gas to be 24 litres mol^{-1}.)

Show your working clearly.

2

6. Hairspray is a mixture of chemicals.

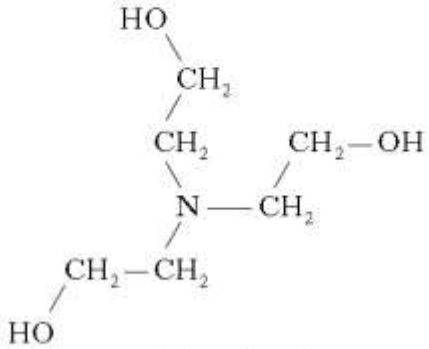
(*a*) A primary alcohol, 2-methylpropan-1-ol, is added to hairspray to help it dry quickly on the hair.



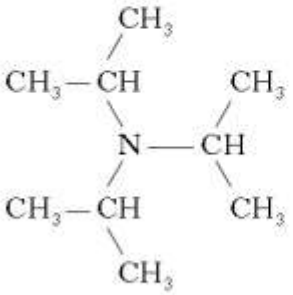
Draw a structural formula for a secondary alcohol that is an isomer of 2-methylpropan-1-ol.

1

(*b*) Triethanol amine and triisopropyl amine are bases used to neutralise acidic compounds in the hairspray to prevent damage to the hair.



triethanol amine



triisopropyl amine

molecular mass	149	molecular mass	143
boiling point	335 °C	boiling point	47 °C

In terms of the intermolecular bonding present, **explain clearly** why triethanol amine has a much higher boiling point than triisopropyl amine.

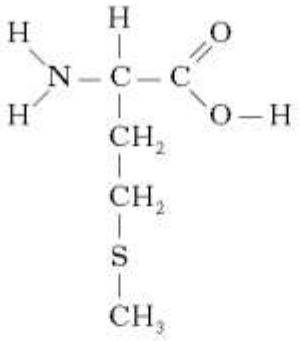
2

DO NOT WRITE IN THIS MARGIN

Marks

7. Paracetamol is a widely used painkiller.

(*b*) One antidote for paracetamol overdose is methionine.

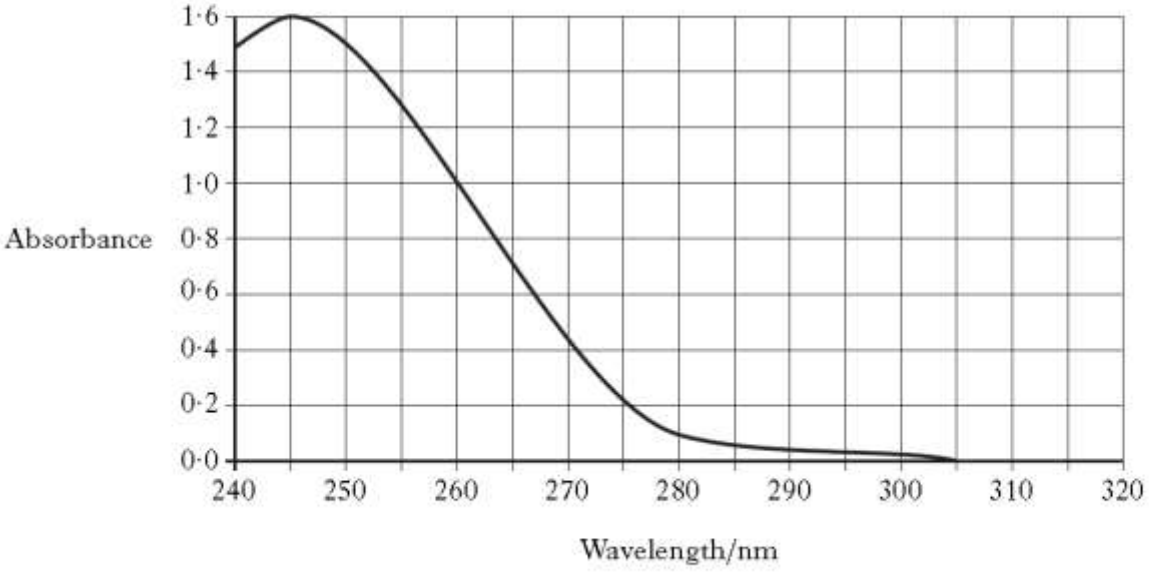


To what family of organic compounds does methionine belong?

1

(*c*) The concentration of paracetamol in a solution can be determined by measuring how much UV radiation it absorbs.

The graph shows how the absorbance of a sample containing $0{\cdot}040\,g\,l^{-1}$ paracetamol varies with wavelength.



The quantity of UV radiation of wavelength 245 nm absorbed is directly proportional to the concentration of paracetamol.

The absorbance of a second sample of paracetamol solution measured at 245 nm was 0·90.

What is the concentration, in $g\,l^{-1}$, of this second paracetamol solution?

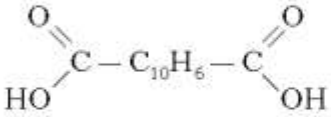
1

DO NOT WRITE IN THIS MARGIN

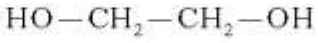
Marks

8. Diols are widely used in the manufacture of polyester polymers.

Polyethylene naphthalate is used to manufacture food containers. The monomers used to produce this polymer are shown.

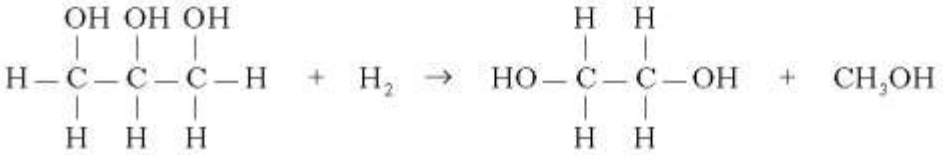


naphthalenedicarboxylic acid



ethane-1,2-diol

(*b*) Ethane-1,2-diol is produced in industry by reacting glycerol with hydrogen.



glycerol ethane-1,2-diol

Excess hydrogen reacts with 27·6 kg of glycerol to produce 13·4 kg of ethane-1,2-diol.

Calculate the percentage yield of ethane-1,2-diol.

Show your working clearly.

2

DO NOT WRITE IN THIS MARGIN

Marks

9. When vegetable oils are hydrolysed, mixtures of fatty acids are obtained. The fatty acids can be classified by their degree of unsaturation.

The table below shows the composition of each of the mixtures of fatty acids obtained when palm oil and olive oil were hydrolysed.

	Palm oil	**Olive oil**
Saturated fatty acids	51%	16%
Monounsaturated fatty acids	39%	75%
Polyunsaturated fatty acids	10%	9%

(*a*) Why does palm oil have a higher melting point than olive oil?

1

(*b*) One of the fatty acids produced by the hydrolysis of palm oil is linoleic acid, $C_{17}H_{31}COOH$.

To which class (saturated, monounsaturated or polyunsaturated) does this fatty acid belong?

1

(*c*) When a mixture of palm oil and olive oil is hydrolysed using a solution of sodium hydroxide, a mixture of the sodium salts of the fatty acids is obtained.

State a use for these fatty acid salts.

1

(3)

[Turn over

DO NOT WRITE IN THIS MARGIN

Marks

10. Christian Schoenbein discovered ozone, O_3, in 1839.

(*a*) Ozone in air can be detected using paper strips that have been soaked in a mixture of starch and potassium iodide solution. The paper changes colour when ozone is present.

Ozone reacts with potassium iodide and water to form iodine, oxygen and potassium hydroxide.

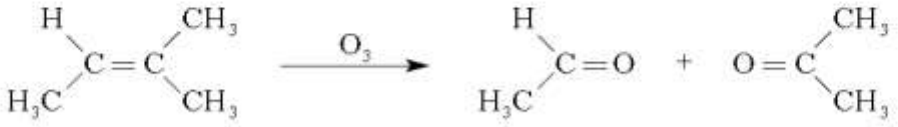
(i) Write the balanced chemical equation for this reaction.

1

(ii) What colour would be seen on the paper when ozone is present?

1

(*c*) When ozone is bubbled through a solution containing an alkene, an ozonolysis reaction takes place.



compound **X** compound **Y**

(i) $2\,cm^3$ of an oxidising agent was added to $5\,cm^3$ of compound **X** in a test tube. After a few minutes a colour change from orange to green was observed.

Name the oxidising agent used.

1

(ii) Draw a structural formula for the alkene which, on ozonolysis, would produce propanal and butan-2-one.

DO NOT WRITE IN THIS MARGIN

Marks

13. Rivers and drains are carefully monitored to ensure that they remain uncontaminated by potentially harmful substances from nearby industries. Chromate ions, CrO_4^{2-}, are particularly hazardous.

(*a*) When chromate ions dissolve in water the following equilibrium is established.

$$\underset{\text{yellow}}{2CrO_4^{2-}(aq)} + 2H^+(aq) \rightleftharpoons \underset{\text{orange}}{Cr_2O_7^{2-}(aq)} + H_2O(\ell)$$

Explain fully the colour change that would be observed when solid sodium hydroxide is added to the solution.

2

(*b*) The concentration of chromate ions in water can be measured by titrating with a solution of iron(II) sulphate solution.

(i) To prepare the iron(II) sulphate solution used in this titration, iron(II) sulphate crystals were weighed accurately into a dry beaker.

Describe how these crystals should be dissolved and then transferred to a standard flask in order to produce a solution of accurately known concentration.

2

(ii) A 50·0 cm^3 sample of contaminated water containing chromate ions was titrated and found to require 27·4 cm^3 of 0·0200 mol l^{-1} iron(II) sulphate solution to reach the end-point.

The redox equation for the reaction is:

$$3Fe^{2+}(aq) + CrO_4^{2-}(aq) + 8H^+(aq) \rightarrow 3Fe^{3+}(aq) + Cr^{3+}(aq) + 4H_2O(\ell)$$

Calculate the chromate ion concentration, in mol l^{-1}, present in the sample of water.

Show your working clearly.

2

DO NOT WRITE IN THIS MARGIN

Marks

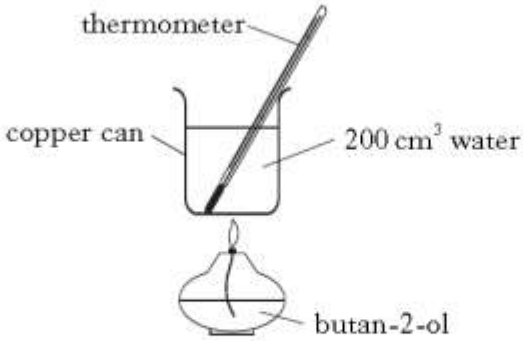
14. The enthalpies of combustion of some alcohols are shown in the table.

Name of alcohol	Enthalpy of combustion/kJ mol^{-1}
methanol	–727
ethanol	–1367
propan-1-ol	–2020

(*a*) Using this data, predict the enthalpy of combustion of butan-1-ol, in kJ mol^{-1}.

1

(*b*) A value for the enthalpy of combustion of butan-2-ol, C_4H_9OH, can be determined experimentally using the apparatus shown.



Mass of butan-2-ol burned = 1·0 g
Temperature rise of water = 40 °C

Use these results to calculate the enthalpy of combustion of butan-2-ol, in kJ mol^{-1}.

2

(*c*) Enthalpy changes can also be calculated using Hess's Law.

The enthalpy of formation for pentan-1-ol is shown below.

$$5C(s) + 6H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_5H_{11}OH(\ell) \qquad \Delta H = -354\,kJ\ mol^{-1}$$

Using this value, and the enthalpies of combustion of carbon and hydrogen from the data booklet, calculate the enthalpy of combustion of pentan-1-ol, in kJ mol^{-1}.

2

DO NOT WRITE IN THIS MARGIN

Marks

16. The boiling point of water can be raised by the addition of a solute.

The increase in boiling point depends only on the **number** of solute particles but not the type of particle.

The increase in boiling point (ΔT_b), in °C, can be estimated using the formula shown.

$$\Delta T_b = 0{\cdot}51 \times c \times i$$

where

c is the concentration of the solution in mol l^{-1}.
i is the number of particles released into solution when one formula unit of the solute dissolves.

The value of i for a number of compounds is shown in the table below.

Solute	**i**
NaCl	2
$MgCl_2$	3
$(NH_4)_3PO_4$	4

(*a*) What is the value of i for sodium sulphate?

1

(*b*) Calculate the increase in boiling point, ΔT_b, for a 0·10 mol l^{-1} solution of ammonium phosphate.

1

Section A

		11	C	21	B		
						32	D
		13	A	23	C	33	D
				24	B	34	A
		15	C	25	D		
6	D						
						37	C
				28	B		
9	C	19	C	29	D		
10	A	20	B				

Mark Scheme				Worth ½	Worth 0
1	(a)	Homogeneous	1		
	(b) (i)	Answer 0·0015 Units not required. (Incorrect units -½)	1	1·80 -1·20 ½ If correct calculation of average rate is carried out using values inaccurately read from the graph, worth ½	
	(ii)	New line should start **at same point as original** and should have a **steeper gradient** (both aspects required for mark) **1 or zero** (No need to consider where their sketched graph finishes/levels off etc)	1		

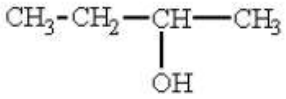
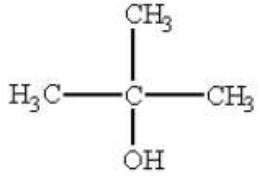
			Mark Scheme		Worth ½	Worth 0
2	(a)	(i)	more protons or increasing nuclear charge	1	More energy required to remove electron/harder to remove electron Or Bigger nuclear pull	Atomic size decreases Size of nucleus increases More electrons Bigger atomic charge
		(ii)	$Cl(g) \rightarrow Cl^+(g) + e^-$ $Cl(g) - e^- \rightarrow Cl^+(g)$ (no penalty if negative sign omitted from electron)	1		$Cl(g) \rightarrow Cl^+ + e^-$
	(b)		Argon does not form (covalent) bonds No electrons involved in bonding	1		It has full outer shell Unreactive/stable

	Mark Scheme		Worth ½	Worth 0
3	(a) Covalent bonds not being broken **OR** Intermolecular bonds that are breaking (accept alternative wording that demonstrates candidate recognises that covalent bonds are not broken when covalent substances melt/boil)	**1**		
	(b) Formula refers to the ratio of Mg^{2+}:Cl^- ions (in lattice) (or alternative wording ie in the lattice there are twice as many chloride ions as magnesium ions) **OR** Mg^{2+} ions surrounded by > 2 Cl^- ions **OR** Cl^- surrounded by >1 Mg^{2+} "chlorine ions" also acceptable	**1**	$MgCl_2$ has a lattice structure or sketch of lattice ½ mark for either	Magnesium chloride has the formula $MgCl_2$, because Mg has a valency of two and Cl has a valency of one. Magnesium chloride has the formula $MgCl_2$, because Mg atoms lose 2 electrons and Cl atoms gain one electron. Magnesium chloride has the formula $MgCl_2$, because Mg^{2+} ions have a charge of 2+ and Cl^- ions have a charge of 1-.

		Mark Scheme		Worth ½	Worth 0
4	(a)	2,2,4-trimethylpentane (do not penalise omission of commas or hyphen)	1	2,2,4-TMP (½)	2,2,4-methylpentane 2,4,4-trimethylpentane

	Mark Scheme		Worth ½	Worth 0
(c)	½ mark for safe heating method (no flame)/water bath ½ mark for condenser of some type ½ mark for methanol and stearic acid or "reactants" ½ mark for (concentrated) sulphuric acid in test tube ½ mark for pouring the mixture into a carbonate solution or solid carbonate added <u>after</u> esterification (correctly labelled diagram acceptable)	2		Acid catalyst (0)

Mark Scheme	Worth ½	Worth 0
5 (a) 1 mole $Ca(OCl)_2 \rightarrow$ 2 moles Cl_2 143 g (½) → 48 litres (½) $\frac{0{\cdot}096}{48} \times 143$ (½) correct substitution = **<u>0·286 g or 0·29 g</u>** (½) (deduct half mark for missing or incorrect unit) NB If 24 l is used in 1st step (i) then answer is 0·572 g (worth 1½) **OR** moles of Cl_2 $\frac{0{\cdot}096}{24} = 0{\cdot}004$ (½) moles of $Ca(OCl)_2$ $\frac{0{\cdot}004}{2} = 0{\cdot}002$ (½) mass of $Ca(OCl)_2$ = 0·002 × <u>143 g</u> (½ for gfm) **<u>= 0·286 g</u>** (½) **2** (deduct half mark for missing or incorrect unit)		

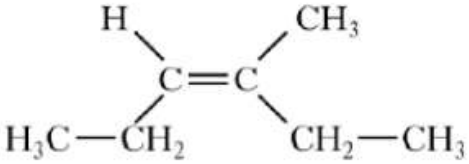
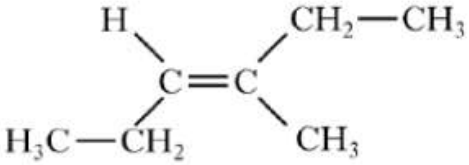
		Mark Scheme		Worth ½	Worth 0
6	(a)	 correct full/shortened/partially shortened structural formula	1	butan-2-ol	
	(b)	triethanol amine has <u>hydrogen bonds</u> (½) (between the molecules) triisopropyl amine molecules has van der Waals/or permanent dipole/permanent dipole attractions or doesn't have H-bonds (½) H-bonds strong(er) (than the dipole/dipole) (½) more energy/higher temp required (to overcome/ break <u>intermolecular forces)</u> (½)	2		

Mark Scheme			Worth ½	Worth 0
7				
(b)	amino acids	**1**	Amines (½) Carboxylic/alkanoic acids (½) Thioethers (½) Sulphides (½) **NB Only one half mark available from this list**	protein
(c)	0·0225 or 0·022 or 0·023 (can be rounded to 0·02 if working shown) deduct ½ for incorrect units	**1**	$\frac{0{\cdot}9}{1{\cdot}6} \times 0{\cdot}04$ (½)	265 0·02 with no working

Mark Scheme	Worth ½	Worth 0
8		Any structure containing

Mark Scheme	Worth ½	Worth 0
(b) EITHER 1 mole glycerol → 1 mole ethane-1,2-diol 92 g → 62 g (½) 27·6 kg → 18·6 kg (½) theoretical yield % yield = $\frac{13{\cdot}4}{18{\cdot}6} \times 100$ (½) % yield = 72 % (½) **OR** moles of glycerol = $\frac{27600}{92}$ moles of glycerol = 300 (½) actual moles ethane-1,2-diol = $\frac{13400}{62}$ actual moles of ethane-1,2-diol = 216·13 (½) % yield = $\frac{216{\cdot}13}{300} \times 100$ (½) % yield = 72 % (½) **2**		% yield = $\frac{13{\cdot}4}{27{\cdot}6} \times 100$ **OR** % yield = 48·6%

		Mark Scheme		Worth ½	Worth 0
9	(a)	Palm oil has lower degree of unsaturated/palm oil less unsaturated/palm oil more saturated/palm oil contains more saturates/fewer double bounds **OR** Molecules in palm oil can pack more closely together "It" is taken to refer to Palm oil if ambiguous	**1**	Intermolecular forces stronger in palm oil (½) The are more intermolecular forces in palm oil (½)	
	(b)	Polyunsaturated	**1**		
	(c)	Soap/emulsifying agent/detergent/washing/cleaning	**1**		

			Mark Scheme		Worth ½	Worth 0
10	(a)	(i)	$O_3 + 2KI + H_2O \rightarrow I_2 + O_2 + 2KOH$ (or any multiples of the above equation) (ignore state symbols)	**1 or 0**		
		(ii)	purple or blue/black or black or blue (only final colour required – ignore any initial colours)	**1 or 0**		Yellow/orange
	(c)	(i)	acidified dichromate (solution)	**1 or 0**		Dichromate solution **(0)**
		(ii)	 **OR**  Correct full/shortened/partially shortened structural formula		3 – methylhex – 3 – ene (½)	

Mark Scheme			Worth ½	Worth 0
13	(a)	On addition of NaOH(s)… • OH^- react with H^+ (½) • concentration of H^+ decreases (½) • equilibrium position to shift to the left (½) • CrO_4^{2-} ion concentration increases (½) **2** [Any three from the list above for up to 1½] Final half mark for solution becomes more yellow/ less orange(½)		
	(b)	(i) Looking for two key points • mention of <u>washings/rinsings</u> (1) • make the (standard) flask up to the mark with water (1)/add water until desired volume reached **2**		

Mark Scheme	Worth ½	Worth 0
(ii) EITHER moles $FeSO_4$ $0{\cdot}02 \times 0{\cdot}0274 = 0{\cdot}000548$ (½) moles of CrO_4^{2-} $\frac{0{\cdot}000548}{3} = 0{\cdot}000183$ (½) Concentration of CrO_4^{2-} $\frac{0{\cdot}000183}{0{\cdot}050}$ (½) $= 0{\cdot}00365$ or $0{\cdot}004$ (mol l^{-1}) (½) **OR** Candidates may use a "titration" formula of which an example is shown below. $\frac{C_1V_1}{b_1} = \frac{C_2V_2}{b_2}$ For inserting the correct "stoichiometric" values in this equation award (½) [eg $b_1 = 1$ if $b_2 = 3$ if the student had decided to make substance "one" the CrO_4^{2-} ion] $\frac{C_1 \times 50{\cdot}0}{1} = \frac{0{\cdot}0200 \times 27{\cdot}4}{3}$ For inserting the correct pairings of concentrations and volumes (volumes can be in litres or in cm^3) (½) $C_1 = \frac{0{\cdot}0200 \times 27{\cdot}4}{3 \times 50{\cdot}0}$ For correct rearrangement (½) Concentration of $CrO_4^{2-} = 0{\cdot}00365$ (mol l^{-1})(½) **2**		

		Mark Scheme		Worth ½	Worth 0
14	(a)	Answer within range -2640 to -2690 No units required	1 or 0		Answer within range 2640 to 2690
	(b)	E = mcΔT = 0·2 (½ mark) × 4·18 × 40 = 33·44 (½) 74 g gives 33·44 × 74 = 2475/2477 kJ Enthalpy of comb. = -2475/-2477 (1) (-½ if incorrect sign) No units required Deduct ½ for incorrect units	2		
	(c)	½ mark for each of the three correctly signed enthalpy change values +354 (½) -5 × 394 or -1970 (½) -6 × 286 or -1716 (½) Addition -3332 (½) Only award addition mark if three "sensible" values used. 3 sensible numbers required to get ½ for the addition based on follow through No units required Deduct ½ for incorrect units	2		

Mark Scheme				Worth ½	Worth 0
16	**(a)**	3	**1**		
	(b)	0·204 (°C) Also accept 0·2 (°C)	 **1**	0·51 × 0·1 × 4 (½)	

[END OF MARKING INSTRUCTIONS]