OCR
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AS Level Chemistry A

H032/01 Breadth in chemistry

Friday 27 May 2016 – Morning

Time allowed: 1 hour 30 minutes

You must have:
- the Data Sheet for Chemistry A (sent with general stationery)

You may use:
- a scientific calculator

First name									
Last name									
Centre number						Candidate number				

INSTRUCTIONS
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the barcodes.

INFORMATION
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- This document consists of **24** pages.

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SECTION A

You should spend a maximum of 25 minutes on this section.

Write your answer to each question in the box provided.

Answer **all** the questions.

1 Which row shows the atomic structure of $^{37}Cl^{-}$?

	protons	neutrons	electrons
A	17	18	20
B	17	20	18
C	18	19	17
D	20	17	21

Your answer ☐ **[1]**

2 What is the formula of ammonium sulfide?

A NH_4S

B NH_4SO_4

C $(NH_4)_2S$

D $(NH_4)_2SO_4$

Your answer ☐ **[1]**

3 Calcium nitrate, $Ca(NO_3)_2$, decomposes when heated, as shown below.

$$Ca(NO_3)_2(s) \rightarrow CaO(s) + 2NO_2(g) + \tfrac{1}{2}O_2(g)$$

A student decomposes 0.00500 mol of $Ca(NO_3)_2$ and collects the gas that is produced.

Calculate the volume of gas that the student should expect to collect, measured at room temperature and pressure.

A 60 cm^3

B 120 cm^3

C 240 cm^3

D 300 cm^3

Your answer ☐ **[1]**

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4 Which equation is **not** a neutralisation reaction?

A $Ca(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2(g)$

B $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

C $K_2CO_3(s) + 2HNO_3(aq) \rightarrow 2KNO_3(aq) + H_2O(l) + CO_2(g)$

D $NH_3(aq) + HCl(aq) \rightarrow NH_4Cl(aq)$

Your answer ☐ **[1]**

5 What is the oxidation number of nitrogen in $Mg(NO_3)_2$?

A –3

B +2

C +5

D +6

Your answer ☐ **[1]**

6 How many orbitals are occupied in a silicon atom?

A 5

B 7

C 8

D 9

Your answer ☐ **[1]**

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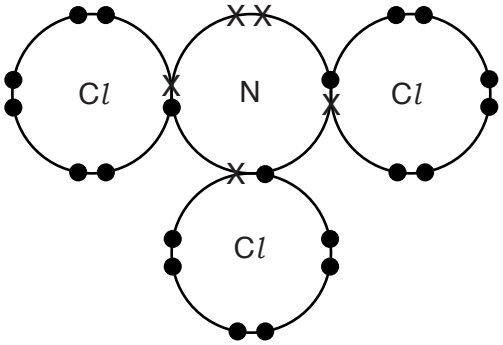
7 A '*dot-and-cross*' diagram for nitrogen trichloride, NCl_3, is shown below.



Which row shows the correct shape and bond angle in a molecule of NCl_3?

	Name of shape	Bond angle
A	Pyramidal	104.5°
B	Pyramidal	107°
C	Tetrahedral	107°
D	Trigonal planar	120°

Your answer ☐ **[1]**

8 What is the shape around the carbon atoms in graphene?

A linear

B pyramidal

C tetrahedral

D trigonal planar

Your answer ☐ **[1]**

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9 Electron configurations for atoms of different elements are shown below.

Which electron configuration represents the element with the largest first ionisation energy?

A $1s^2 2s^2$

B $1s^2 2s^2 2p^4$

C $1s^2 2s^2 2p^6$

D $1s^2 2s^2 2p^6 3s^2$

Your answer ☐ **[1]**

10 Successive ionisation energies of four elements in Period 3 are shown below.

Which letter could represent magnesium?

	Ionisation energy / kJ mol^{-1}				
	1st	**2nd**	**3rd**	**4th**	**5th**
A	1251	2298	3822	5159	6542
B	738	1451	7733	10543	13630
C	496	4563	6913	9544	13352
D	578	1817	2745	11577	14842

Your answer ☐ **[1]**

11 A student adds aqueous sodium carbonate to one test-tube and aqueous silver nitrate to a second test-tube.
The student adds dilute sulfuric acid to each test-tube.

Which row has the correct observations?

	Aqueous sodium carbonate	**Aqueous silver nitrate**
A	no change	precipitate
B	no change	no change
C	effervescence	no change
D	effervescence	precipitate

Your answer ☐ **[1]**

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12 The enthalpy change of formation of butane can be calculated using the enthalpy changes of combustion, $\Delta_c H$, below.

Substance	C(s)	$H_2(g)$	$C_4H_{10}(g)$
$\Delta_c H$ / kJ mol^{-1}	–394	–286	–2877

Calculate the enthalpy change of formation of $C_4H_{10}(g)$.

$$4C(s) + 5H_2(g) \rightarrow C_4H_{10}(g)$$

A –2197 kJ mol^{-1}

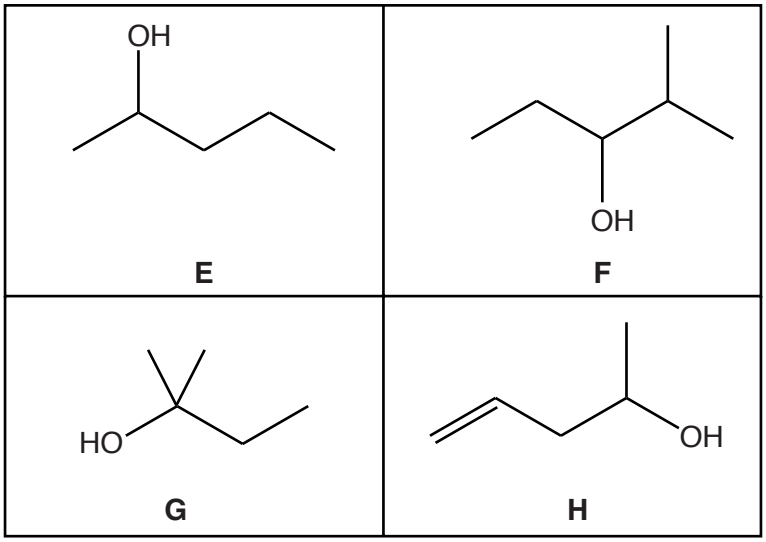
B –129 kJ mol^{-1}

C +129 kJ mol^{-1}

D +2197 kJ mol^{-1}

Your answer ☐ **[1]**

13 The skeletal formulae of four alcohols, **E**, **F**, **G** and **H**, are shown below.



Which pair of alcohols are structural isomers of each other?

A **E** and **F**

B **E** and **G**

C **E** and **H**

D **F** and **G**

Your answer ☐ **[1]**

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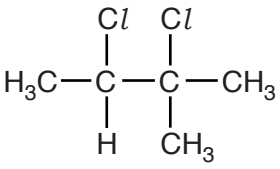
14 What is the name of the following compound?



A 1,2-dichloro-1,2-dimethylpropane

B 2,3-dichloro-2,3-dimethylpropane

C 2,3-dichloro-2-methylbutane

D 2,3-dichloro-3-methylbutane

Your answer ☐ **[1]**

15 Which compound has non-polar molecules?

A *E*-1,2-dichlorobut-2-ene

B *E*-2,3-dichlorobut-2-ene

C *Z*-2,3-dichlorobut-2-ene

D *Z*-1,4-dichlorobut-2-ene

Your answer ☐ **[1]**

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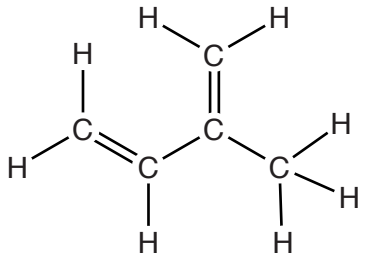
16 The displayed formula for a hydrocarbon is shown below.



How many σ and π bonds are present in a molecule of this hydrocarbon?

	σ bonds	**π bonds**
A	2	4
B	10	2
C	10	4
D	12	2

Your answer ☐ **[1]**

17 Chlorine reacts with 1-chloropropane in the presence of ultraviolet radiation via a radical substitution mechanism.

Which equation shows a propagation step in the mechanism for this reaction?

A $Cl_2 \rightarrow \bullet Cl + \bullet Cl$

B $\bullet Cl + \bullet C_3H_6Cl \rightarrow C_3H_6Cl_2$

C $C_3H_7Cl + \bullet Cl \rightarrow C_3H_6Cl_2 + \bullet H$

D $\bullet Cl + C_3H_7Cl \rightarrow \bullet C_3H_6Cl + HCl$

Your answer ☐ **[1]**

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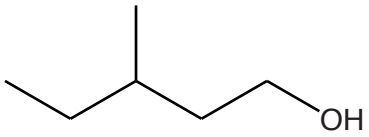
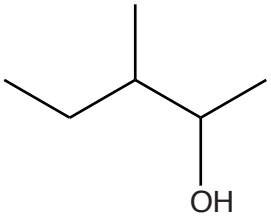
18 Which alcohol can be oxidised by $K_2Cr_2O_7$ and H_2SO_4 to form a ketone?

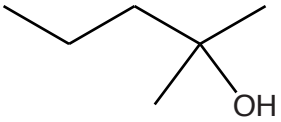
A



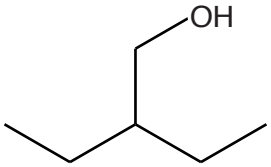
B



C



D



Your answer ☐ **[1]**

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19 A reaction sequence is shown below:

Step 1 $CH_3CH{=}CHCH_3 + HBr \rightarrow CH_3CH_2CHBrCH_3$

Step 2 $CH_3CH_2CHBrCH_3 + NaOH \rightarrow CH_3CH_2CH(OH)CH_3 + NaBr$

Which type of reaction mechanism is involved in each step?

	Step 1	Step 2
A	electrophilic addition	electrophilic substitution
B	electrophilic addition	nucleophilic substitution
C	nucleophilic addition	electrophilic substitution
D	nucleophilic addition	nucleophilic substitution

Your answer ☐ **[1]**

20 When heated with NaOH(aq), 1-iodobutane is hydrolysed at a much faster rate than 1-chlorobutane.

Which statement explains the different rates?

A The C–I bond enthalpy is greater than the C–C*l* bond enthalpy.

B The C–I bond is less polar than the C–C*l* bond.

C The C–I bond has a C atom with a greater $\delta+$ charge than in the C–C*l* bond.

D The C–I bond requires less energy to break than the C–C*l* bond.

Your answer ☐ **[1]**

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Turn over for the next question

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SECTION B

Answer **all** the questions.

21 A twenty pence coin contains copper and nickel.

(a) Copper and nickel each exist as a mixture of isotopes.

State the similarities and differences between the atomic structure of isotopes of the **same** element.

Similarities .....

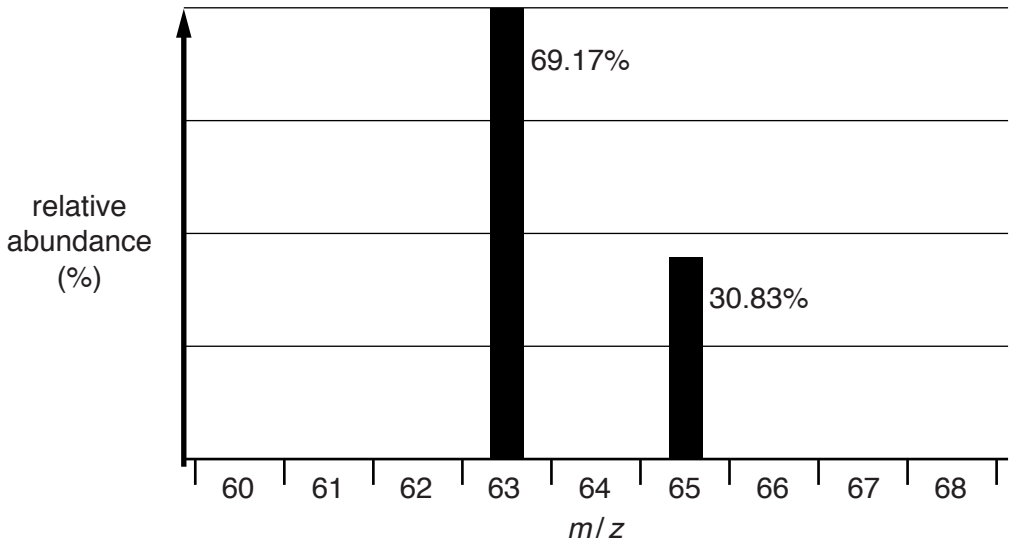
.....

Differences .....

.....

[2]

(b) The copper used to make a batch of coins is analysed by mass spectrometry. The mass spectrum is shown below.



(i) Calculate the relative atomic mass of the copper used to make the coins.

Give your answer to **two** decimal places.

relative atomic mass = ... **[2]**

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(ii) One coin has a mass of 5.00 g and contains 84.0% of copper, by mass.

Calculate the number of copper atoms in one coin.

Give your answer in standard form and to **three** significant figures.

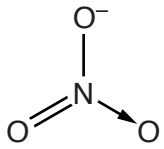
number of copper atoms = ... **[2]**

(c) Nickel(II) nitrate, $Ni(NO_3)_2$, can be prepared by reacting nickel(II) oxide with dilute nitric acid.

(i) Write the equation for this reaction.

..... **[1]**

(ii) $Ni(NO_3)_2$ contains the NO_3^- ion. The nitrogen atom bonds to the oxygen atoms with a single covalent bond, a double covalent bond and a dative covalent bond, as shown below.



Draw the '*dot-and-cross*' diagram for the NO_3^- ion, showing outer shell electrons only. Use a different symbol for the extra electron.

[2]

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22 This question is about several salts.

(a) A hydrated salt, compound **A**, is analysed and has the following percentage composition by mass:

Cr, 19.51%; C*l*, 39.96%; H, 4.51%; O, 36.02%.

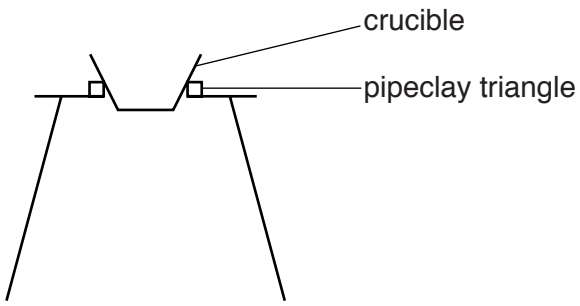
Calculate the formula of compound **A**, showing clearly the water of crystallisation.

Show your working.

formula of compound **A** = ... **[3]**

(b) A student carries out an experiment to determine the amount of water of crystallisation in the formula of another hydrated salt. The student intends to remove the water by heating the hydrated salt.

A diagram of the apparatus used by the student is shown below.



- The student adds the hydrated salt to the crucible and weighs the crucible and contents.
- The student heats the crucible and contents and allows them to cool.
- The student weighs the crucible and residue.

The student's results are shown below.

Mass of crucible + hydrated salt / g	16.84
Mass of crucible + residue after heating / g	16.26

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(i) The maximum error in each mass measurement using the balance is ±0.005 g.

Calculate the percentage error in the mass of water removed.

percentage error = ... % **[1]**

(ii) Suggest **one** modification that the student could make to their method to reduce the percentage error in the mass of water removed.

.....

.....

..... **[1]**

(iii) The student is not sure that all the water of crystallisation has been removed.

How could the student modify the experiment to be confident that all the water of crystallisation has been removed?

.....

.....

..... **[1]**

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(c) A student prepares a solution of sodium sulfate, Na_2SO_4, by adding 6.25×10^{-2} mol dm^{-3} sulfuric acid, H_2SO_4, from a burette to 25.0 cm^3 of 0.124 mol dm^{-3} NaOH in a conical flask.

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

Calculate the minimum volume of the H_2SO_4 that the student would need to completely react with the NaOH present.

volume of H_2SO_4 = ... cm^3 **[3]**

(d) Salts can also be prepared in redox reactions of metals with acids.
A student prepares a solution of aluminium sulfate by reacting aluminium with dilute sulfuric acid.

$$2Al(s) + 3H_2SO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + 3H_2(g)$$

Using oxidation numbers, show which element has been oxidised and which has been reduced in this reaction. State the changes in oxidation numbers, including all signs.

element oxidised.....

oxidation number change: from ..... to .....

element reduced .....

oxidation number change: from ..... to.....

[2]

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23 This question is about properties of the halogens and halide ions.

(a) Bromine can be extracted by bubbling chlorine gas through concentrated solutions containing bromide ions.

(i) Write the electron configuration of a bromide ion, in terms of sub-shells.

..... **[1]**

(ii) Write an ionic equation for this reaction and state why this reaction takes place in terms of reactivity of the halogens.

.....

.....

.....

..... **[2]**

(b) Chlorine is used in water treatment.

State **one** benefit and **one** risk of chlorine in water treatment.

Benefit .....

.....

Risk .....

..... **[1]**

(c) Precipitation reactions can be used to distinguish between halide ions.

(i) State the reagent needed for these precipitation reactions.

..... **[1]**

(ii) How would the appearance of the precipitates allow you to distinguish between chloride, bromide and iodide ions?

Chloride .....

Bromide .....

Iodide .....

[1]

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24 Aqueous lead(II) nitrate, $Pb(NO_3)_2(aq)$, and aqueous potassium iodide, KI(aq), react together. The equation is shown below.

$$Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$$

A student carries out an experiment to determine the enthalpy change of reaction, $\Delta_r H$, of this reaction.

The student follows the method outlined below.

- Add 50.0 cm^3 of 1.50 mol dm^{-3} $Pb(NO_3)_2(aq)$ to a polystyrene cup.
- Measure out 50.0 cm^3 of a solution of KI(aq), which is in excess.
- Measure the temperature of both solutions.
- Add the KI(aq) to the polystyrene cup, stir the mixture and record the maximum temperature.

Temperature readings

Initial temperature of both solutions	= 19.5 °C
Maximum temperature of mixture	= 30.0 °C

(a) Calculate $\Delta_r H$, in kJ mol^{-1}, for the reaction shown in the equation above.

Give your answer to an **appropriate** number of significant figures.

Assume that the density of all solutions and specific heat capacity, *c*, of the reaction mixture is the same as for water.

$\Delta_r H$ = ... kJ mol^{-1} **[4]**

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(b) Write an ionic equation for the reaction that the student carries out.

Include state symbols.

..... **[1]**

(c) The 50.0 cm^3 of KI(aq) used in the experiment contains 10% more KI than is needed to react with 50.0 cm^3 of 1.50 mol dm^{-3} $Pb(NO_3)_2$(aq).

$$Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$$

Calculate the concentration, in mol dm^{-3}, of KI that the student used.

concentration of KI = ... mol dm^{-3} **[2]**

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25 Sulfur trioxide, SO_3, is used for the industrial manufacture of sulfuric acid.

SO_3 is produced by reacting sulfur dioxide, SO_2, and oxygen, O_2, as shown in **equilibrium 25.1** below.

Equilibrium 25.1 $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \quad \Delta H = -197\,kJ\,mol^{-1}$

(a) Le Chatelier's principle can be used to predict how different conditions affect the equilibrium position.

- Using le Chatelier's principle, show that a low temperature and a high pressure should be used to obtain a maximum **equilibrium** yield of SO_3.
- Explain why the actual conditions used in industry may be different from the conditions needed for a maximum equilibrium yield.

.....

.....

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..... **[5]**

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(b) Under certain conditions, K_c for **equilibrium 25.1** is 0.160 $dm^3 mol^{-1}$.

The equilibrium mixture under these conditions has the following concentrations of SO_2 and O_2.

Species	Equilibrium concentration / mol dm^{-3}
SO_2	2.00
O_2	1.20

- Using the value of K_c, explain whether the equilibrium position will be towards the right or towards the left under these conditions.
- Calculate the concentration of SO_3 in the equilibrium mixture.

.....

.....

.....

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..... **[4]**

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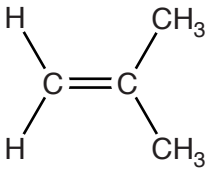
26 Compound **B**, shown below, can be used to synthesise organic compounds with different functional groups.



Compound B

(a) **(i)** Compound **B** is a member of a homologous series.

Name the homologous series and state its general formula.

Homologous series .....

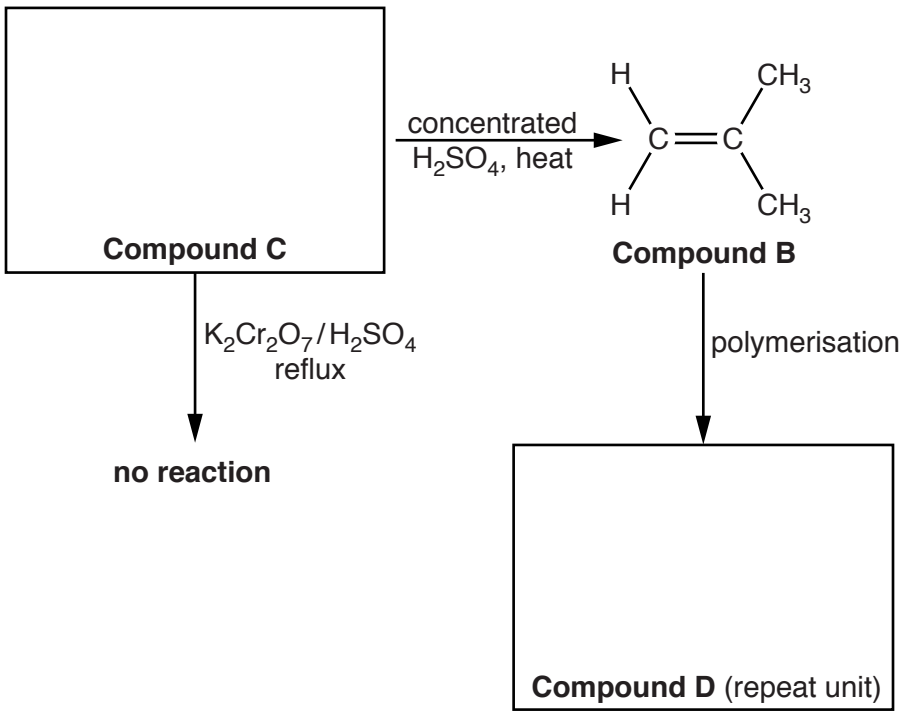
General formula ..... **[1]**

(ii) What reagents and conditions are needed to convert compound **B** into a saturated hydrocarbon?

..... **[1]**

(b) Some reactions involving compound **B** are shown in the flowchart below.

Complete the flowchart, showing the structures of organic compounds **C** and **D**.



[2]

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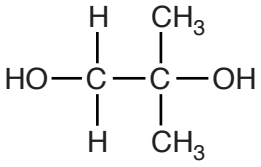
(c) The structure of compound **F** is shown below.



Compound F

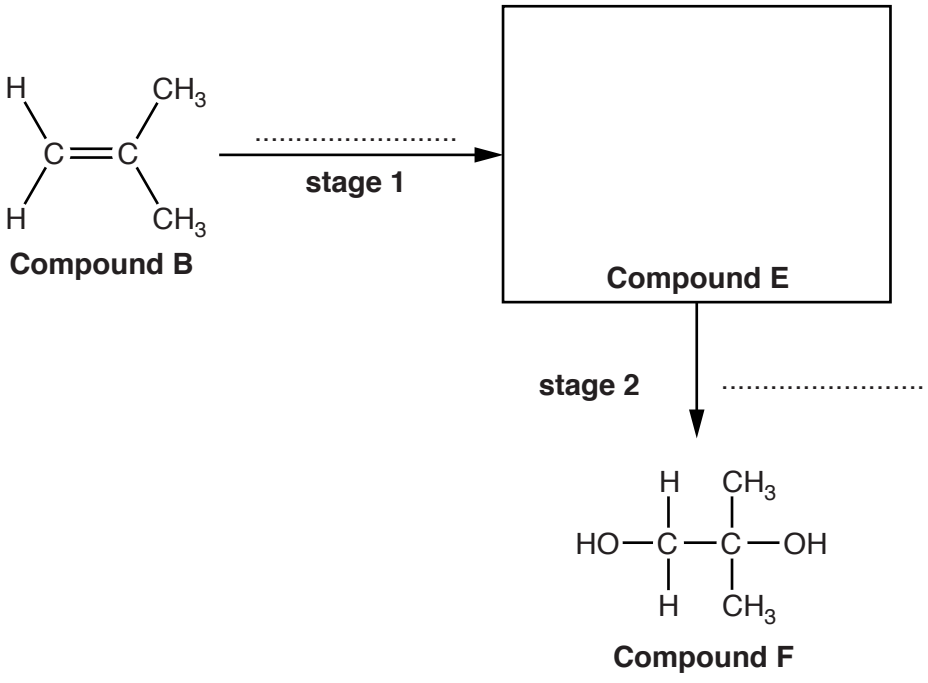
(i) What is the empirical formula of compound **F**?

..... **[1]**

(ii) A student plans a two-stage synthesis for preparing compound **F** from compound **B.**

The synthesis first prepares compound **E**, as shown in the flowchart.

Draw the structure of compound **E** in the box and state the reagents for each stage on the dotted lines.



Compound B

Compound E

Compound F

[3]

END OF QUESTION PAPER

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