Oxford Cambridge and RSA

Tuesday 06 October 2020 – Afternoon

AS Level Chemistry A

H032/01 Breadth in chemistry

Time allowed: 1 hour 30 minutes

You must have:
- the Data Sheet for Chemistry A

You can use:
- a scientific or graphical calculator
- an HB pencil

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number ☐☐☐☐☐ Candidate number ☐☐☐☐

First name(s) ____________________

Last name ____________________

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- This document has **20** pages.

ADVICE
- Read each question carefully before you start your answer.

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SECTION A

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

Answer **all** the questions.

Write your answer to each question in the box provided.

1 Which substance contains polar molecules?

A C_2H_4

B CO_2

C NCl_3

D SF_6

Your answer ☐ **[1]**

2 What is the formula of silver carbonate?

A $AgCO_3$

B $Ag(CO_3)_2$

C Ag_2CO_3

D Ag_3CO_3

Your answer ☐ **[1]**

3 Which statement explains why ice is less dense than water?

A Hydrogen bonds are stronger in ice than in water.

B Hydrogen bonds hold H_2O molecules apart in ice.

C Ice is a solid but water is a liquid.

D Ice contains hydrogen bonds, but water does not contain hydrogen bonds.

Your answer ☐ **[1]**

4 Some Group 2 compounds can be used to neutralise acid soils and to treat acid indigestion.

Which Group 2 compound would **not** be suitable for either use?

A $BaSO_4$

B $CaCO_3$

C $Ca(OH)_2$

D $Mg(OH)_2$

Your answer ☐ **[1]**

5 Which p-block element contains atoms with one unpaired electron?

A Al

B Si

C P

D S

Your answer ☐ **[1]**

6 The equation for a redox reaction is shown below.

$2HClO_3 + 2HCl \rightarrow 2ClO_2 + Cl_2 + 2H_2O$

Which statement is correct?

A Cl is both oxidised and reduced.

B Cl is oxidised and O is reduced.

C O is both oxidised and reduced.

D O is oxidised and Cl is reduced.

Your answer ☐ **[1]**

7 Potassium ferrate(VI) contains two potassium ions for every ferrate(VI) ion.

What is the formula of the ferrate(VI) ion?

A FeO_3^{2-}

B FeO_4^{2-}

C FeO_5^{2-}

D FeO_6^{2-}

Your answer ☐ **[1]**

8 The unbalanced equation for the reaction of copper with concentrated nitric acid is shown below.

.........Cu + ...HNO_3 → ....$Cu(NO_3)_2$ + ...NO_2 + ...H_2O

What is the number of moles of HNO_3 that react with 1 mole of Cu?

A 2

B 3

C 4

D 6

Your answer ☐ **[1]**

9 2.0 dm^3 of Cl_2 gas reacts with 2.0 dm^3 of ClF_3 gas to form 6.0 dm^3 of a gaseous compound. The reaction has 100% atom economy and all volumes are measured at the same temperature and pressure.

What is the molecular formula of the compound formed?

A ClF

B Cl_2F_3

C Cl_3F_2

D Cl_3F_3

Your answer ☐ **[1]**

10 Which sample contains the greatest number of molecules?

A 1 g of methanol, CH_3OH

B 2 g of nitrogen dioxide, NO_2

C 3 g of phosphorus, P_4

D 4 g of iodine, I_2

Your answer ☐ **[1]**

11 Hydrogen and oxygen react as shown below.

$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$ $\Delta_r H = -486\ \text{kJ mol}^{-1}$

Bond enthalpies are shown in the table.

Bond	H−H	O=O
Bond enthalpy / kJ mol^{-1}	+436	+498

What is the bond enthalpy, in kJ mol^{-1}, for the O−H bond?

A +221

B +355

C +464

D +928

Your answer ☐ **[1]**

12 Hydrogen gas can be produced as shown below.

$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta H = +206\,kJ\,mol^{-1}$

Which conditions produce the greatest equilibrium yield of hydrogen?

A Low temperature and high pressure

B Low temperature and low pressure

C High temperature and high pressure

D High temperature and low pressure

Your answer ☐ **[1]**

13 The reversible reaction below is in equilibrium.

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

The equilibrium concentrations are shown in the table.

Substance	$SO_2(g)$	$O_2(g)$	$SO_3(g)$
Equilibrium concentration / $mol\,dm^{-3}$	4.00	2.40	1.44

What is the numerical value of K_c?

A 0.0375

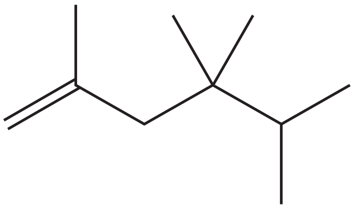
B 0.0540

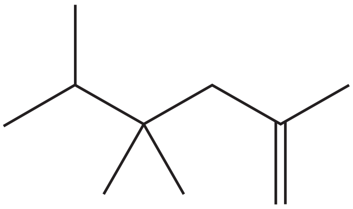
C 0.150

D 18.5

Your answer ☐ **[1]**

14 Which statement is correct for the two structures below?





A They have the same empirical formula.

B They have different relative molecular masses.

C They are structural isomers.

D They have different functional groups.

Your answer ☐ **[1]**

15 Which property explains the low reactivity of alkanes?

A Electron pair repulsion between σ-bonds

B Free rotation about σ-bonds

C High C–C bond enthalpy

D High polarity of the C–H bonds

Your answer ☐ **[1]**

16 What are the correct reagents for the conversion below?

$CH_3CH_2CHOHCH_3 \rightarrow CH_3CH_2CHBrCH_3$

A Br_2 and H_2SO_4

B Br_2 and NaOH

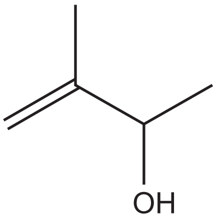
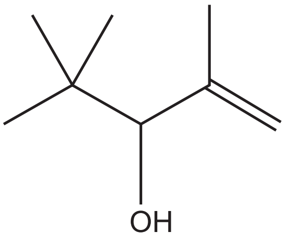
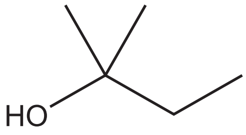
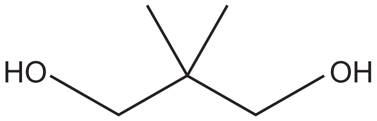
C NaBr and H_2SO_4

D NaBr and NaOH

Your answer ☐ **[1]**

17 Which compound could react with **both**

- $K_2Cr_2O_7/H_2SO_4$ in an oxidation reaction **and**
- an acid catalyst (e.g. H_2SO_4) in an elimination reaction?

A	
B	
C	
D	

Your answer ☐ **[1]**

18 A student reacts 24.24 g of 2-bromobutane in the reaction below.

$$CH_3CH_2CHBrCH_3 + NaOH \rightarrow CH_3CH_2CHOHCH_3 + NaBr$$
$M_r = 136.9$ $M_r = 74.0$

The reaction produces 4.81 g of $CH_3CH_2CHOHCH_3$.

What is the percentage yield of $CH_3CH_2CHOHCH_3$?

A 10.7%

B 19.8%

C 36.7%

D 54.1%

Your answer ☐ **[1]**

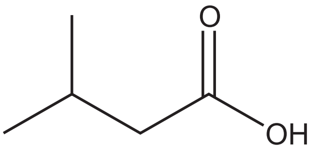
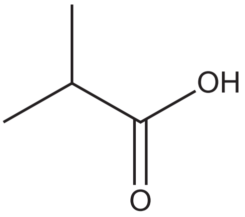
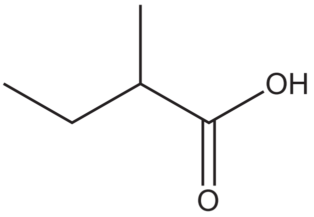
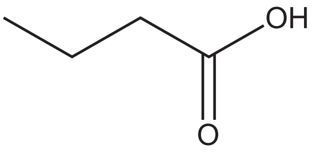
19 Which row describes a nucleophile?

A	electron pair donor	attracted to high electron density
B	electron pair donor	attracted to low electron density
C	electron pair acceptor	attracted to high electron density
D	electron pair acceptor	attracted to low electron density

Your answer ☐ **[1]**

20 The mass spectrum of a carboxylic acid contains peaks at *m*/*z* = 29 and *m*/*z* = 102.

Which compound could have produced the spectrum?

A	
B	
C	
D	

Your answer ☐ **[1]**

SECTION B

Answer **all** the questions.

21 This question is about atoms, isotopes and mass spectrometry.

(a) Complete the table to show the number of electrons that can fill the first four shells.

Shell	**1st shell**	**2nd shell**	**3rd shell**	**4th shell**
Number of electrons				

[1]

(b) Most elements contain atoms of different isotopes.

State any differences and similarities between the atomic structures of isotopes of the same element.

Differences ....

....

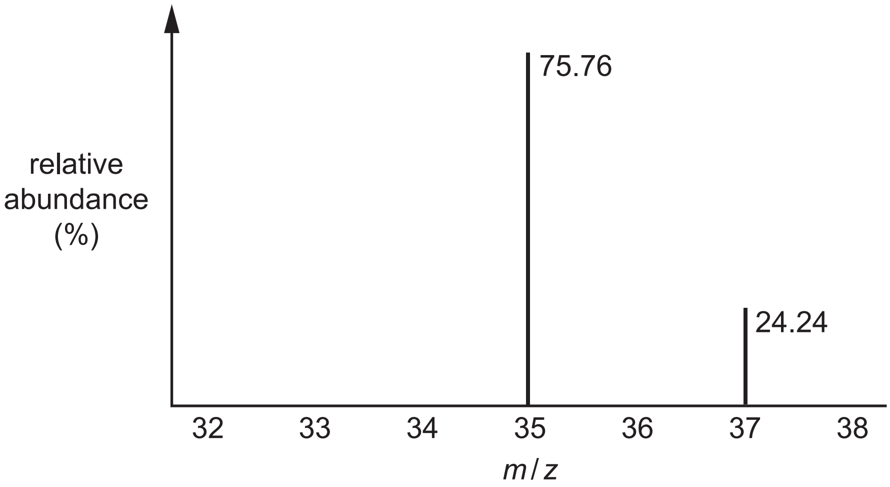
Similarities ....

....

[2]

(c) Mass spectrometry can be used to identify the isotopes of chlorine.

Part of the mass spectrum of chlorine is shown below.



(i) Calculate the relative atomic mass of chlorine.

Give your answer to **2** decimal places.

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

(ii) The mass spectrum of chlorine, Cl_2, also contains three molecular ion, M^+, peaks. One of the M^+ peaks has an m/z value of 72.

Suggest why an M^+ peak at $m/z = 72$ is observed and predict the m/z values of the other two M^+ peaks.

Peak at $m/z = 72$ ....

....

....

m/z values of the other two M^+ peaks ....
[2]

22 This question is about compounds of bromine.

(a) Bromine reacts with phosphorus, P_4, to form phosphorus tribromide, PBr_3.

(i) Complete the electron configuration of a bromine atom.

$1s^2$ .... **[1]**

(ii) Write the equation for the reaction of phosphorus with bromine.

.... **[1]**

(b) A compound of bromine is a solid at room temperature. The electrical conductivity of the compound at different physical states is shown in the table.

Physical state	**Electrical conductivity**
solid	poor
liquid	good

Name the type of lattice in the compound at room temperature and explain the different electrical conductivities.

Name of lattice ....

Explanation for different conductivities ....

....

....

....
[2]

(c) Bromine reacts with fluorine to form compound **A**.

Compound **A** is a liquid at room temperature and pressure but can easily be vaporised.

When vaporised, 0.428 g of **A** produces 76.0 cm^3 of gas at 1.00×10^5 Pa and 100 °C.

Determine the molar mass and molecular formula of compound **A**.

molar mass of **A** = ... g mol^{-1}

molecular formula of **A** = ...

[5]

23 This question is about barium hydroxide.

(a) Barium hydroxide is an alkali which releases hydroxide ions, OH^-, in aqueous solution.

A barium hydroxide solution contains 3.89 g of $Ba(OH)_2$ in 100 cm^3 at 20 °C.

Calculate the concentration of hydroxide ions, OH^-, in $mol\,dm^{-3}$, of this solution at 20 °C.

Give your answer to **3** significant figures.

concentration of OH^- ions = ... $mol\,dm^{-3}$ **[3]**

(b) A student carries out a titration to determine the concentration of an aqueous solution of $Ba(OH)_2$.

The student adds 25.0 cm^3 of the $Ba(OH)_2(aq)$ solution to a conical flask.
The student titrates this solution by adding 0.160 $mol\,dm^{-3}$ $HNO_3(aq)$ from the burette.

The equation is shown below.

$Ba(OH)_2(aq) + 2HNO_3(aq) \rightarrow Ba(NO_3)_2(aq) + 2H_2O(l)$

The student repeats the titration until concordant titres are obtained.

The mean titre of 0.160 $mol\,dm^{-3}$ $HNO_3(aq)$ is 26.75 cm^3.

(i) What is meant by concordant titres?

....

.... **[1]**

(ii) Calculate the concentration, in mol dm^{-3}, of the $Ba(OH)_2(aq)$ solution.

concentration of $Ba(OH)_2(aq)$ = ... mol dm^{-3} **[3]**

(c) A student plans to prepare a solution of $Ba(OH)_2$ from barium by two different reaction routes.

Outline **2** reaction routes for preparing a solution of $Ba(OH)_2$ from barium in the laboratory.

Include relevant equations.

....

....

....

....

....

....

.... **[4]**

24 This question is about making ammonia, NH_3.

(a) Ammonia is manufactured by reacting nitrogen with hydrogen:

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

Standard enthalpy changes of combustion, $\Delta_c H^\ominus$, are given in the table.

Substance	**$\Delta_c H^\ominus$ / kJ mol^{-1}**
$N_2(g)$	+180
$H_2(g)$	–286
$NH_3(g)$	–293

Calculate the standard enthalpy change of formation, $\Delta_f H^\ominus$, for $NH_3(g)$.

$\Delta_f H^\ominus$ for $NH_3(g)$ = ... kJ mol^{-1} **[3]**

(b) The industrial manufacture of NH_3 from N_2 and H_2 is carried out at an increased temperature and in the presence of a catalyst.

Explain, using Boltzmann distributions, why increasing the temperature and using a catalyst both increase the reaction rate.

....

....

....

....

....

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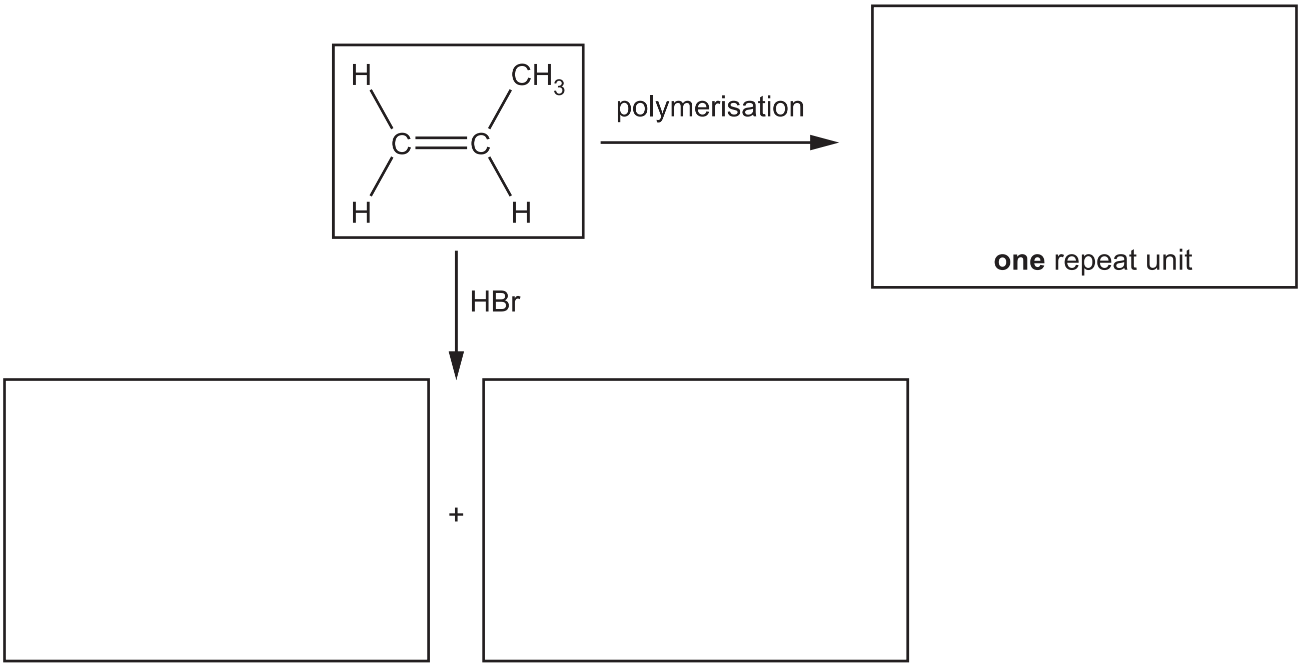
.... **[5]**

25 This question is about unsaturated hydrocarbons.

(a) Two reactions of propene are shown below.

In the boxes, show the structures of the organic products of the reactions.

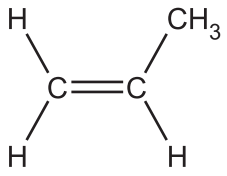


[3]

(b) Propene also reacts with bromine.

Outline the mechanism for the reaction of propene with bromine, Br_2.
The structure of propene has been provided.

Show curly arrows, relevant dipoles and product(s).



[4]

(c) The ‘alkynes’ is a homologous series of hydrocarbons.

The table shows three alkynes.

Alkyne	**Structural formula**	**Molecular formula**
ethyne	HC≡CH	C_2H_2
propyne	$CH_3C≡CH$	C_3H_4
but-1-yne	$CH_3CH_2C≡CH$	C_4H_6

(i) Explain what is meant by the term: **homologous series**.

....

....

.... **[2]**

(ii) Suggest the general formula of the alkynes.

.... **[1]**

(iii) Propyne reacts with bromine to form a saturated compound.

Write an equation for the reaction, showing the structure of the organic product.

[2]

(iv) But-1-yne is a structural isomer of C_4H_6.

Draw the structures of **2** other structural isomers of C_4H_6.

[2]

(v) Draw the structure of 2,5-dimethylhept-3-yne.

[1]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).