Oxford Cambridge and RSA

Tuesday 5 October 2021 – Afternoon

AS Level Chemistry B (Salters)

H033/01 Foundations of chemistry

Time allowed: 1 hour 30 minutes

You must have:
- the Data Sheet for Chemistry B

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 A compound has a high melting point and does not conduct electricity when solid or molten.

What is the structure of the compound?

A Giant covalent network

B Giant ionic

C Giant metallic

D Simple molecular

Your answer ☐ **[1]**

2 Which statement is correct for the properties of strontium hydroxide?

A It does not react with dilute acids.

B It is alkaline in solution.

C It is more soluble than barium hydroxide.

D It reacts with water to form strontium oxide.

Your answer ☐ **[1]**

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3 Which expression is the definition of atom economy?

A $\frac{\text{amount (mol) of desired product}}{\text{total amount (mol) of products}} \times 100$

B $\frac{\text{mass of desired product}}{\text{total mass of reactants}} \times 100$

C $\frac{\text{relative formula mass of desired product}}{\text{sum of relative formula masses of all reactants}} \times 100$

D $\frac{\text{total mass of reactants}}{\text{total mass of products}} \times 100$

Your answer ☐ **[1]**

4 A chemical company is looking for a new 'greener' process.

Which feature of the new process, compared with the old one, would the company choose?

A It has more reaction steps.

B It produces more waste products.

C It uses catalysts that are more selective.

D It uses more organic solvents.

Your answer ☐ **[1]**

5 What is the formula of chromium(III) oxide?

A Cr_3O

B Cr_3O_2

C Cr_2O_3

D CrO_3

Your answer ☐ **[1]**

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6 Which statement is correct for an endothermic reaction?

A Heat is given out.

B More bonds are made than broken.

C More energy is taken in to break bonds than is given out in making bonds.

D The reaction has a negative activation enthalpy.

Your answer ☐ **[1]**

7 How many σ and π bonds are there in a molecule of propene, $CH_3CH{=}CH_2$?

	σ	π
A	1	2
B	6	2
C	7	1
D	8	1

Your answer ☐ **[1]**

8 The overall equation for the electrolysis of aqueous chlorides to make chlorine is given below.

$2Cl^-(aq) + 2H_2O(l) \rightarrow Cl_2(g) + 2OH^-(aq) + H_2(g)$

Which statement is correct for this process?

A Chloride ions are reduced.

B Chlorine is produced at the negative electrode.

C Hydrogen atoms in water are reduced.

D The pH does not change as the reaction proceeds.

Your answer ☐ **[1]**

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9 Which statement about the action of concentrated acids on halides is correct?

A Chlorides form HCl and H_2S when reacted with sulfuric acid.

B HBr can be prepared by the action of phosphoric acid on a bromide.

C Iodides do not react with phosphoric acid.

D Iodides form only HI and SO_2 when reacted with sulfuric acid.

Your answer ☐ **[1]**

10 What volume of CO_2 (measured at RTP) is formed when 0.10 mol of Na_2CO_3 reacts with excess hydrochloric acid?

A $2.4\,cm^3$

B $4.8\,cm^3$

C $2400\,cm^3$

D $4800\,cm^3$

Your answer ☐ **[1]**

11 The bond between carbon and chlorine can be represented as $C^{\delta+}$– $Cl^{\delta-}$.

Which statement is correct?

A All compounds containing C – Cl bonds have permanent dipole – permanent dipole bonds.

B Carbon is more electronegative than chlorine.

C Electrons are evenly distributed in the C – Cl bond.

D The C – F bond is more polar than C – Cl.

Your answer ☐ **[1]**

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12 What is a correct property of a phenol?

A It fizzes with sodium carbonate solution.

B It is neutralised by sodium hydroxide.

C It reacts with carboxylic acids to form esters.

D It reacts with iron(III) chloride to form a brown colour.

Your answer ☐ **[1]**

13 Which statement about recrystallisation is correct?

A Insoluble impurities remain until the end.

B Soluble impurities are filtered off at the start.

C The crystals formed at the end are filtered off.

D The solid must be equally soluble in the solvent at all temperatures.

Your answer ☐ **[1]**

14 Boron has electron configuration $1s^2 2s^2 2p^1$.

Which statement is correct for a boron atom?

A Each s-orbital contains 1 electron.

B It has three sub-shells that contain electrons.

C It has three unpaired electrons.

D It has two orbitals.

Your answer ☐ **[1]**

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15 Which row matches the correct systematic name and formula?

	Formula	Systematic Name
A	CuO	copper(I) oxide
B	HNO_2	nitric(V) acid
C	PbO_2	lead(IV) oxide
D	NaC*l*O	sodium chlorate(II)

Your answer ☐ **[1]**

16 $V\,m^3$ of a gas weighs m g at a pressure p Pa.

What is the M_r of the gas?

A $\frac{mRT}{pV}$

B $\frac{pV}{mRT}$

C $\frac{mpV}{RT}$

D $\frac{RTV}{mp}$

Your answer ☐ **[1]**

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17 Methane reacts with oxygen as shown below.

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

In several experiments, 10 cm^3 of methane is completely reacted with 20 cm^3 of oxygen.

The temperature and pressure remain the same throughout each experiment.

Which statement is correct for these experiments?

A 10 cm^3 of oxygen remain after reaction.

B 30 cm^3 of carbon dioxide are formed.

C The volume does not change if the temperature is above 100 °C.

D The volume halves if the temperature is below 100 °C.

Your answer ☐ **[1]**

18 Which compound has the highest boiling point?

A CH_3CH_2OH

B CH_3COOH

C CH_3CHO

D CH_3OCH_3

Your answer ☐ **[1]**

19 A sample of air contains 0.0367% CO_2 and 1.8 ppm of CH_4.

What is the correct ratio of CO_2 to CH_4 in the sample of air (to 1 significant figure)?

A 0.005:1

B 0.02:1

C 20:1

D 200:1

Your answer ☐ **[1]**

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20 Which row correctly describes the homologous series of the compound shown?

	Compound	**Homologous series**
A	CH_3COOCH_3	ester
B	C_6H_5OH	alcohol
C	CH_3OCH_3	acid anhydride
D	CH_3CHO	acid

Your answer ☐ **[1]**

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SECTION B

Answer **all** the questions.

21 Chemists compare the chemistry of calcium and barium.

(a) **(i)** Why is it valid for chemists to compare the chemistry of calcium and barium?

.....

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

(ii) How does the first ionisation enthalpy of calcium compare with that of barium?

Give a reason for your answer.

.....

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

(iii) Barium and calcium both react with water.

Complete the equation for the reaction of barium with water.

$$Ba(s) + ...H_2O(l) \longrightarrow$$

[2]

(b) Barium sulfate, $BaSO_4$, is used as a 'barium meal'. People swallow this so that the contents of their gut will show up better under X-rays.

(i) The high M_r of $BaSO_4$ makes it absorb X-rays well, compared with $CaSO_4$.
Give the M_r values of $CaSO_4$ and $BaSO_4$.

$CaSO_4$ ..... $BaSO_4$ ..... **[1]**

(ii) Barium salts are toxic but $BaSO_4$ is insoluble and this is why $BaSO_4$ can be used as a barium meal.

The insolubility of barium sulfate is used as a test in qualitative analysis.

State what the test identifies, how the test is carried out and what is observed.

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

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(c) Barium carbonate decomposes when heated. A student says that it decomposes more readily than calcium carbonate because the Ba^{2+} ion is larger than the Ca^{2+} ion and therefore not so strongly attracted to the CO_3^{2-} ion.

Which part(s) of the student's statement is/are correct? Give the correct chemistry for the incorrect part(s).

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

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22 Phenyl ethanoate is used to flavour sweets.

A group of students make phenyl ethanoate.

The students dissolve 15 g of phenol in sodium hydroxide, cool with ice and add 24 g of ethanoic anhydride.

(a) The reaction is:

$$\underset{\text{phenol}}{C_6H_5OH} + \underset{\text{ethanoic anhydride}}{(CH_3CO)_2O} \rightarrow \underset{\text{phenyl ethanoate}}{C_6H_5OCOCH_3} + \underset{\text{ethanoic acid}}{CH_3COOH}$$

Equation 22.1

(i) Draw the **skeletal** formula for phenyl ethanoate.

[1]

(ii) Which reagent is in excess?

Show your calculations.

reagent in excess is ..... **[2]**

(b) After some other purification stages, the students end up with phenyl ethanoate (boiling point 196 °C) dissolved in a liquid of boiling point 170 °C.

Name the separation process they use to produce pure phenyl ethanoate.

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

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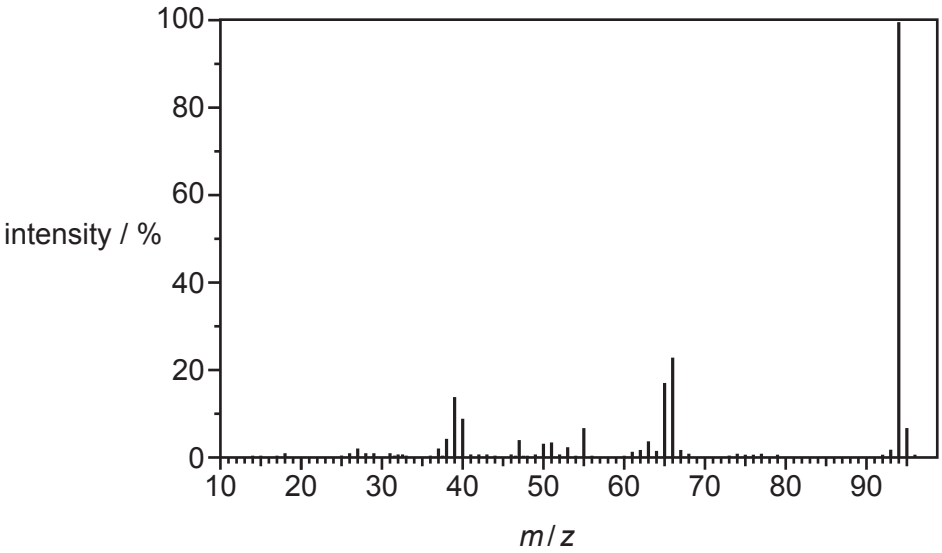
(c) The mass spectrum of phenol is shown below.

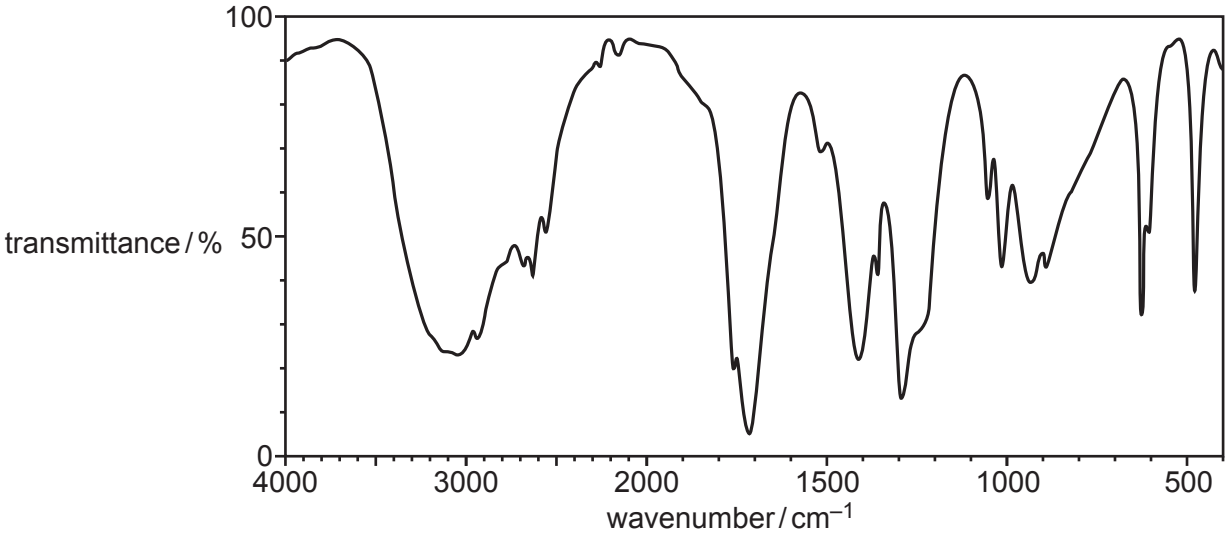


Give the formula of the ion that causes the peak at m/z = 95.

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

(d) $C_6H_5OH + (CH_3CO)_2O \rightarrow C_6H_5OCOCH_3 + CH_3COOH$ **Equation 22.1**

An infrared spectrum of one of the compounds in **equation 22.1** is shown below.



Identify the compound, giving reasons, including wavenumbers of peaks.

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..... **[3]**

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23 Scientists study the atomic emission spectrum of the Sun to find out about its composition.

(a) Describe the appearance of an atomic emission spectrum and explain how such a spectrum is caused.

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

(b) Helium was discovered from its line in the emission spectrum of the Sun at 588 nm.

(i) Calculate the frequency of this line. (1 nm = 1×10^{-9} m)
Give your answer to an **appropriate** number of significant figures.

frequency = ... Hz **[3]**

(ii) Another line has a frequency of 5.00×10^{14} Hz.

Calculate the electron energy change corresponding to this frequency and give its units.

energy change ..... units ..... **[2]**

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(iii) The line in **part (b)(ii)** is in the visible region of the spectrum. Name a region of the electromagnetic spectrum that has **less** energy associated with it.

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

(c) Complete **Table 23.1** for atoms of the isotopes of helium.

	^{3}He	^{4}He
atomic number		
number of electrons		
number of neutrons		
mass number		

[2]

Table 23.1

(d) Titanium is another element formed by nuclear fusion.

(i) **Table 23.2** shows the stable isotopes of titanium and their abundances.

Isotope	^{46}Ti	^{47}Ti	^{48}Ti	^{49}Ti	^{50}Ti
Percentage abundance	8.25	7.44	73.72	5.41	5.18

Table 23.2

Calculate the relative atomic mass of titanium from these data.

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

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

(ii) Complete the electron configuration of titanium.

$1s^2 2s^2 2p^6 3s^2$ ..... **[1]**

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24 Scientists have experimented with adding butan-1-ol to diesel fuel to try to get more power from the fuel and to reduce pollutants.

Some of their results are shown below.

	15% butan-1-ol/diesel mixture compared with pure diesel	
	Low weight on vehicle	**High weight on vehicle**
Power per volume of fuel	more power	more power
CO emissions	little difference	less CO
NO_x emissions	little difference	more NO_x

(a) **(i)** Apart from giving more power, give **one** other advantage of adding butan-1-ol to diesel and explain why this is important.

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

(ii) Explain how NO_x is formed in a vehicle engine.

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

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(b) Some students measure $\Delta_c H$ for butan-1-ol.

They use a spirit burner and a beaker of water.

(i) Complete a labelled diagram of their apparatus.

spirit burner containing butan-1-ol

[2]

(ii) The students find that the combustion of 2.5 g of butan-1-ol raises the temperature of 200 cm^3 of water by 52 °C.

Calculate their value for $\Delta_c H$ for butan-1-ol, $C_4H_9OH(l)$.

$\Delta_c H$ = ... $kJ\,mol^{-1}$ **[3]**

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(c) **(i)** Use the data below to complete a Hess cycle and calculate $\Delta_c H^{\ominus}$ for butan-1-ol, $C_4H_9OH(l)$.

Substance	$\Delta_f H^{\ominus}$ **/ kJ mol^{-1}**
$C_4H_9OH(l)$	–327
$CO_2(g)$	–394
$H_2O(l)$	–286

$$C_4H_9OH + 6O_2 \longrightarrow 4CO_2 + 5H_2O$$

$\Delta_c H^{\ominus}$ = ... kJ mol^{-1} **[2]**

(ii) Suggest **one** reason why the answers to parts **(b)(ii)** and **(c)(i)** are not the same.

.....

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

(d) Butan-1-ol reacts with carboxylic acids to form esters in the presence of concentrated sulfuric acid.

Complete the equation for the formation of the ester and another product below.

$$C_4H_9OH + CH_3COOH \longrightarrow \qquad\qquad +$$

[2]

END OF QUESTION PAPER

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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).

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