A

AQA

Surname ______________________________

Other Names __________________________

Centre Number ________________________

Candidate Number _____________________

Candidate Signature ___________________

AS
CHEMISTRY

Paper 1 Inorganic and Physical Chemistry

7404/1

Monday 20 May 2019 Morning

Time allowed: 1 hour 30 minutes

At the top of the page, write your surname and other names, your centre number, your candidate number and add your signature.

[Turn over]

JUN197404101

For this paper you must have:

- **the Periodic Table/Data Sheet, provided as an insert (enclosed)**
- **a ruler with millimetre measurements**
- **a scientific calculator, which you are expected to use where appropriate.**

INSTRUCTIONS

- **Use black ink or black ball-point pen.**
- **Answer ALL questions.**
- **You must answer the questions in the spaces provided. Do NOT write on blank pages.**
- **All working must be shown.**
- **Do all rough work in this book. Cross through any work you do not want to be marked.**

INFORMATION

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

ADVICE

You are advised to spend about 65 minutes on SECTION A and 25 minutes on SECTION B.

DO NOT TURN OVER UNTIL TOLD TO DO SO

SECTION A

Answer ALL questions in this section.

0 1

This question is about compounds that contain fluorine.

0 1 . 1

Sodium fluoride contains sodium ions (Na^+) and fluoride ions (F^-).
Na^+ and F^- have the same electron configuration.

Explain why a fluoride ion is larger than a sodium ion. [2 marks]

[Turn over]

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0 1 . 2

Explain, in terms of structure and bonding, why the melting point of sodium fluoride is high. [2 marks]

0 1 . 3

The ion H_2F^+ is formed when hydrogen fluoride gains a proton as shown in the equation

$$HF + H^+ \longrightarrow H_2F^+$$

Name the type of bond formed when HF reacts with H^+
Explain how this bond is formed.
[2 marks]

Type of bond ______________________________

Explanation ______________________________

____

____

____

____

____

____

____

[Turn over]

0 1 . 4

Fluoroantimonic acid contains two ions, SbF_6^- and H_2F^+

Draw the shape of the SbF_6^- ion and the shape of the H_2F^+ ion. Include any lone pairs that influence the shape.

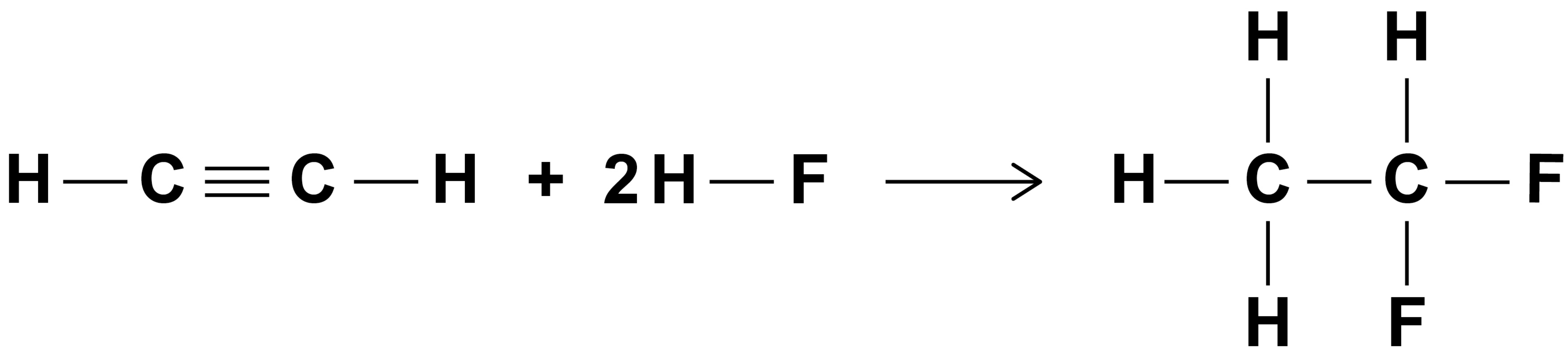
Name the shape of each ion. [4 marks]

	SbF_6^-	H_2F^+
Shape		
Name of shape		

[Turn over]

0 1 . 5

Hydrogen fluoride reacts with ethyne (C_2H_2) as shown in the equation. All compounds are in the gaseous state.



ΔH = –179 kJ mol^{-1}

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[Turn over]

TABLE 1 shows some mean bond enthalpy data.

TABLE 1

Bond	C–H	C≡C	H–F	C–C
Mean bond enthalpy / kJ mol^{-1}	412	837	562	348

Use the data in TABLE 1 to calculate a value for the bond enthalpy of a C–F bond in the product. [3 marks]

C–F bond enthalpy ______________________ kJ mol^{-1}

[Turn over]

13

0 2

Time of flight (TOF) mass spectrometry is an important analytical technique.

A mixture of three compounds is analysed using a TOF mass spectrometer.
The mixture is ionised using electrospray ionisation.
The three compounds are known to have the molecular formulas:

$C_3H_5O_2N$

$C_3H_7O_3N$

$C_3H_7O_2NS$

0 2 . 1

Describe how the molecules are ionised using electrospray ionisation. [3 marks]

02.2

Give the formula of the ion that reaches the detector first in the TOF mass spectrometer. [1 mark]

[Turn over]

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0 2 . 3

A sample of germanium is analysed in a TOF mass spectrometer using electron impact ionisation.

Give an equation, including state symbols, for the process that occurs during the ionisation of a germanium atom. [1 mark]

[Turn over]

02.4

In the TOF mass spectrometer, a germanium ion reaches the detector in 4.654×10^{-6} s
The kinetic energy of this ion is 2.438×10^{-15} J
The length of the flight tube is 96.00 cm

The kinetic energy of an ion is given by the equation

$$KE = \frac{1}{2}mv^2$$

where
m = mass / kg
v = speed / m s^{-1}

The Avogadro constant
$L = 6.022 \times 10^{23}$ mol^{-1}

**Use this information to calculate the mass, in g, of one mole of these germanium ions.
Use your answer to state the mass number of this germanium ion. [5 marks]**

Mass of one mole of germanium ions

___________________ **g**

Mass number of ion

____

[Turn over]

10

0 3

This question is about chromium and its compounds.

0 3 . 1

Complete the full electron configuration of a chromium atom. [1 mark]

$1s^2$ ______________________________

0 3 . 2

An atom has 2 more protons and 3 more neutrons than an atom of ^{52}Cr.

Deduce the symbol, including the mass number and the atomic number, for this atom. [1 mark]

____

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[Turn over]

0 3 . 3

A sample of chromium contains four isotopes and has a relative atomic mass of 52.09

TABLE 2 shows the mass number and the percentage abundance of three of these isotopes.

TABLE 2

Mass number	52	53	54
Abundance (%)	82.8	10.9	2.7

Determine the percentage abundance of the fourth isotope.
Show by calculation that the mass number of this isotope is 50 [3 marks]

Percentage abundance

____

Calculation

[Turn over]

0 3 . 4

Deduce the oxidation state of chromium in the $Cr_2O_7^{2-}$ ion. [1 mark]

0 3 . 5

Iodide ions can be oxidised to iodine using $Cr_2O_7^{2-}$ ions.

Deduce a half-equation to show the oxidation of iodide ions to iodine.

State symbols are NOT required.
[1 mark]

03.6

Deduce a half-equation for the conversion in acidic solution of $Cr_2O_7^{2-}$ ions to Cr^{3+} ions.

State symbols are NOT required.
[1 mark]

03.7

Use your answers from questions 03.5 and 03.6 to deduce the overall redox equation for the reaction between iodide ions and acidified $Cr_2O_7^{2-}$ ions.

State symbols are NOT required.
[1 mark]

0 4

The first ionisation energies of the elements in Period 2 change as the atomic number increases.

Explain the pattern in the first ionisation energies of the elements from lithium to neon. [6 marks]

[Turn over]

6

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[Turn over]

0 5

Nitrogen monoxide reacts with chlorine to form nitrosyl chloride (NOCl).

$$2\,NO(g) + Cl_2(g) \rightleftharpoons 2\,NOCl(g)$$

0 5 . 1

1.50 mol of NO are mixed with 1.00 mol of Cl_2 and the mixture is left to reach equilibrium at a given temperature.
The equilibrium mixture contains 0.350 mol of NOCl

Calculate the amount, in moles, of NO and of Cl_2 in the equilibrium mixture.
[2 marks]

Amount of NO ____________________ mol

Amount of Cl_2 ____________________ mol

[Turn over]

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0 5 . 2

Give the expression for the equilibrium constant, K_c, for the reaction between nitrogen monoxide and chlorine to form nitrosyl chloride. [1 mark]

K_c =

[Turn over]

0 5 . 3

A different equilibrium mixture is prepared in a flask of volume 800 cm^3 at a different temperature.
At equilibrium this mixture contains 0.850 mol of NO and 0.458 mol of Cl_2

For the reaction at this temperature $K_c = 1.32 \times 10^{-2}\ mol^{-1}\ dm^3$

Determine the amount, in moles, of NOCl in this equilibrium mixture. [4 marks]

Amount of NOCl ____________________ mol

7

[Turn over]

0 6

A student does an investigation to determine the relative formula mass, M_r, of a solid unknown diprotic acid, H_2A

$$H_2A + 2\,NaOH \rightarrow Na_2A + 2\,H_2O$$

- **250 cm^3 of aqueous solution are prepared using 1300 mg of H_2A**
- **A pipette is used to add 25.0 cm^3 of 0.112 mol dm^{-3} aqueous sodium hydroxide to a conical flask.**
- **This aqueous sodium hydroxide is titrated with the acid solution.**

The titration results are shown in TABLE 3.

TABLE 3

	Rough	1	2	3
Final volume / cm^3	27.35	26.75	38.90	35.70
Initial volume / cm^3	0.00	0.35	12.15	9.20
Titre / cm^3	27.35	26.40	26.75	26.50

[Turn over]

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0 6 . 1

Use the results to calculate the M_r of H_2A
[5 marks]

M_r of H_2A ______________________________

[Turn over]

06.2

The uncertainty in using the pipette in this experiment is ±0.06 cm^3

Calculate the percentage uncertainty in using the pipette. [1 mark]

% uncertainty ____________________________

06.3

Before adding the solution from the burette in the rough titration, there was an air bubble below the tap.
At the end of this titration the air bubble was not there.

Explain why this air bubble increases the final burette reading of the rough titration. [1 mark]

0 6 . 4

During the titration the student washed the inside of the conical flask with some distilled water.

Suggest why this washing does NOT give an incorrect result. [1 mark]

0 7

This question is about the reactions of magnesium and its compounds.

0 7 . 1

Magnesium is used in one of the stages in the extraction of titanium.

Give an equation for the reaction between titanium(IV) chloride and magnesium.
State the role of magnesium in this reaction. [2 marks]

Equation

____

Role of magnesium ______________________________

____

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[Turn over]

07.2

A mixture of magnesium oxide and magnesium hydroxide has a mass of 3200 mg

This mixture is reacted with carbon dioxide to form magnesium carbonate and water. The mass of water produced is 210 mg

$$Mg(OH)_2 + CO_2 \longrightarrow MgCO_3 + H_2O$$

$$MgO + CO_2 \longrightarrow MgCO_3$$

Calculate the percentage by mass of magnesium oxide in this mixture.
[4 marks]

% of magnesium oxide

____

6

[Turn over]

0 8

The following pairs of compounds, each in aqueous solution, can be distinguished by simple test-tube reactions.

Give a reagent, or combination of reagents, that can be added to the solutions in each pair to distinguish between them in a single reaction.

State what is observed in each case.

0 8 . 1

$NaCl(aq)$ and $BaCl_2(aq)$ [3 marks]

Reagent ______________________________

____

Observation with NaCl

____

____

Observation with $BaCl_2$

____

____

0 8 . 2

$NaCl(aq)$ and $Na_2CO_3(aq)$ [3 marks]

Reagent ______________________________

____

Observation with $NaCl(aq)$

____

____

Observation with $Na_2CO_3(aq)$

____

____

6

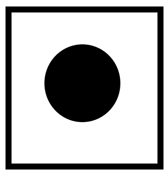
[Turn over]

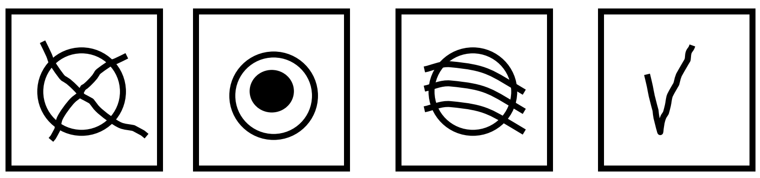
SECTION B

Answer ALL questions in this section.

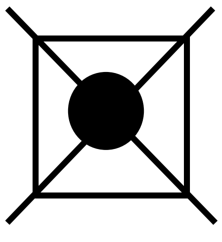
Only ONE answer per question is allowed.

For each answer completely fill in the circle alongside the appropriate answer.

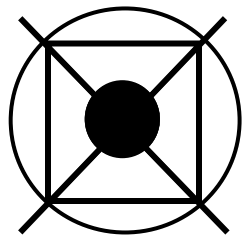
CORRECT METHOD 

WRONG METHODS 

If you want to change your answer you must cross out your original answer as shown.



If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown.



You may do your working in the blank space around each question but this will not be marked.
Do NOT use additional sheets for this working.

[Turn over]

0 9

Which sample, measured at room temperature and pressure, contains the greatest number of the stated particles?
[1 mark]

- ○ **A** 1 g of hydrogen molecules
- ○ **B** 1 g of helium atoms
- ○ **C** 1 dm^3 of hydrogen molecules
- ○ **D** 1 dm^3 of helium atoms

10

5.0 g of an oxide of molybdenum contain 4.0 g of molybdenum.

What is the empirical formula of this oxide? [1 mark]

- ○ **A** MoO_2
- ○ **B** Mo_4O_5
- ○ **C** Mo_2O_3
- ○ **D** Mo_3O_2

[Turn over]

1 1

Which substance has delocalised electrons? [1 mark]

- ○ **A graphite**
- ○ **B iodine**
- ○ **C sodium chloride**
- ○ **D tetrachloromethane**

12

Which species is NOT pyramidal in shape? [1 mark]

○ **A** PF_3

○ **B** H_3O^+

○ **C** CH_3^-

○ **D** BF_3

[Turn over]

1 3

Which change occurs when water is vaporised? [1 mark]

- ○ **A** An exothermic change occurs.
- ○ **B** Covalent bonds are broken.
- ○ **C** Intermolecular forces are overcome.
- ○ **D** The total energy of the molecules decreases.

14

Which equation represents the reaction that has a standard enthalpy change equal to the standard enthalpy of formation for barium chloride? [1 mark]

○ **A** $Ba(g) + Cl_2(g) \longrightarrow BaCl_2(s)$

○ **B** $Ba^{2+}(g) + 2Cl^{-}(g) \longrightarrow BaCl_2(s)$

○ **C** $Ba(s) + Cl_2(g) \longrightarrow BaCl_2(s)$

○ **D** $Ba^{2+}(s) + 2Cl^{-}(g) \longrightarrow BaCl_2(s)$

[Turn over]

1 5

Which equation does NOT represent a redox reaction? [1 mark]

○ **A** $Mg + 2HCl \longrightarrow MgCl_2 + H_2$

○ **B** $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

○ **C** $Fe + CuSO_4 \longrightarrow FeSO_4 + Cu$

○ **D** $CuO + 2HCl \longrightarrow CuCl_2 + H_2O$

16

Which property would you expect the element radium, Ra, to possess?
[1 mark]

○ **A** It forms a soluble sulfate.

○ **B** It does not react with water.

○ **C** It is a good conductor of electricity.

○ **D** It forms a covalent fluoride.

[Turn over]

17

Which statement is NOT correct?
[1 mark]

○ **A** Strontium has a lower first ionisation energy than calcium.

○ **B** Strontium has a larger ionic radius than calcium.

○ **C** Strontium reacts less vigorously with water than calcium.

○ **D** Strontium hydroxide is more soluble in water than calcium hydroxide.

18

Which property of the Group 2 elements, Ca to Ba, increases with increasing atomic number? [1 mark]

- ○ **A** Atomic Radius
- ○ **B** Electronegativity
- ○ **C** First ionisation energy
- ○ **D** Melting Point

[Turn over]

19

What is the best oxidising agent?
[1 mark]

- ○ **A** F_2
- ○ **B** F^-
- ○ **C** I_2
- ○ **D** I^-

20

Some fuel in a spirit burner is burned, and the heat produced is used to heat a container of water.

In this experiment:

The mass of water heated = m g

The temperature rise = y °C

The specific heat capacity of water = c J K^{-1} g^{-1}

What is the amount of heat energy absorbed by the water? [1 mark]

- ○ **A** mcy
- ○ **B** $mc\,(y + 273)$
- ○ **C** $y\,/\,mc$
- ○ **D** $(y + 273)\,/\,mc$

[Turn over]

21

The equation below represents the complete combustion of butane.

$$C_4H_{10}(g) + 6\frac{1}{2}\,O_2(g) \longrightarrow$$

$$4CO_2(g) + 5H_2O(g)$$

20 cm^3 of butane are completely burned in 0.20 dm^3 of oxygen.
Which statement is correct?

All volumes are measured at the same temperature and pressure. [1 mark]

- A $40\ cm^3$ of carbon dioxide are formed

- B $0.065\ dm^3$ of oxygen react

- C $70\ cm^3$ of oxygen remain

- D $0.50\ dm^3$ of steam are formed

[Turn over]

22

Which statement is correct about reactions involving halide ions? [1 mark]

○ **A** Sodium chloride forms chlorine when added to concentrated sulfuric acid.

○ **B** Sodium chloride forms chlorine when added to bromine.

○ **C** Sodium bromide forms bromine when added to concentrated sulfuric acid.

○ **D** Sodium bromide forms bromine when added to iodine.

2 3

What is the percentage yield when 20 g of aluminium are produced from 50 g of aluminium oxide?

$$2Al_2O_3 \longrightarrow 4Al + 3O_2$$

[1 mark]

○ **A 76%**

○ **B 40%**

○ **C 33%**

○ **D 19%**

15

END OF QUESTIONS

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For Examiner's Use	
Question	Mark
1	
2	
3	
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7	
8	
Section B	
TOTAL	

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