2021 ASSESSMENT MATERIALS

AS CHEMISTRY

Physical and Inorganic Chemistry

Total number of marks: 45

0 6 This question is about shapes of molecules and ions.

Draw the shape of NCl_3 and of NCl_4^+

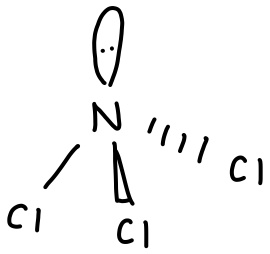
Include any lone pairs of electrons that influence the shape.

Name the shape of NCl_3

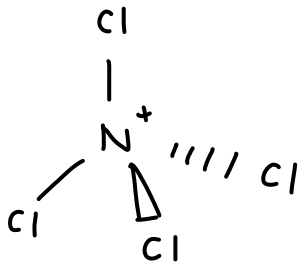
State and explain the bond angle in NCl_4^+

[5 marks]

Shape of NCl_3



Shape of NCl_4^+



Name of shape of NCl_3 trigonal pyramidal

Bond angle in NCl_4^+ 109.5°

Explanation of bond angle in NCl_4^+ there are 4 bonding pairs and no lone pairs, so there is equal repulsion between any 2 bonding pairs

0 9 . 3 Silicon tetrafluoride (SiF_4) is a tetrahedral molecule.

Deduce the type of intermolecular forces in SiF_4

Explain how this type of intermolecular force arises and why no other type of intermolecular force exists in a sample of SiF_4

[3 marks]

Intermolecular forces in SiF_4 london dispersion forces

Explanation The molecule is symmetrical so it is non-polar and there are no permanent dipole-dipole interactions. There are no hydrogen bonds as there are no hydrogen present.

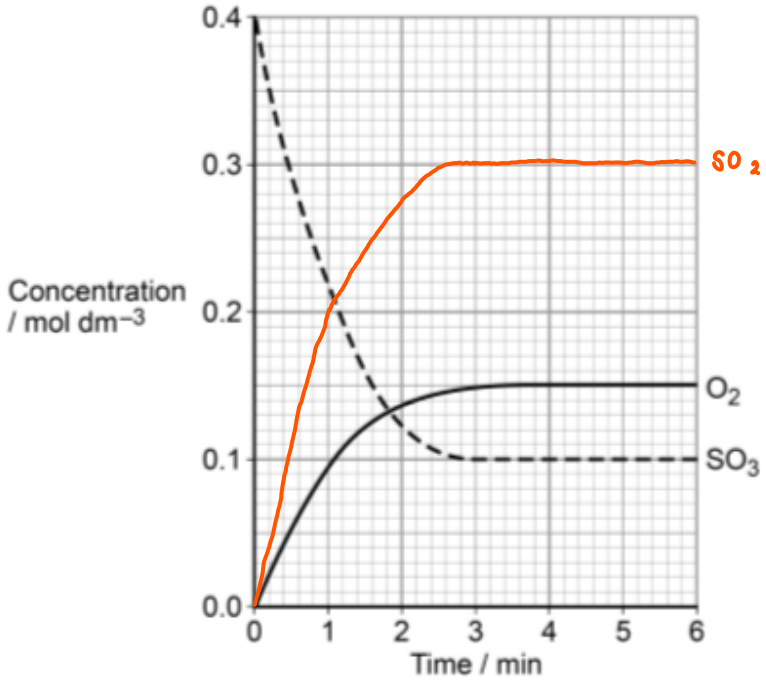
0 5 This question is about equilibrium.

Sulfur trioxide decomposes to form sulfur dioxide and oxygen at temperature T_1 according to the equilibrium shown.

$$2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g) \qquad \Delta H = +196 \text{ kJ mol}^{-1}$$

The graph in **Figure 4** shows the concentrations of sulfur trioxide and of oxygen over a period of 6 minutes at temperature T_1

Figure 4



0 5 . 1 State the time, to the nearest minute, when equilibrium is first established. Explain your answer.

[2 marks]

Time 3 minutes

Explanation concentration of O_2 and SO_3 are constant

0 5 . 2 Sketch on the graph in **Figure 4** how the concentration of sulfur dioxide changes over these 6 minutes at temperature T_1

[2 marks]

0 5 . 3 The temperature of the mixture was changed to T_2 and the mixture left to establish a new equilibrium.
In the new equilibrium mixture the concentration of sulfur trioxide was found to be 0.07 mol dm^{-3}

Deduce which of T_1 and T_2 is the higher temperature.
Explain your deduction.

[2 marks]

Higher temperature T1

Explanation The forward reaction is endothermic. At higher temperature, equilibrium shifts to the right so concentration of SO_3 is lower.

0 5 This question is about Group 2 elements and their compounds.

0 5 . 1 Explain why the melting point of magnesium is higher than the melting point of sodium.

[2 marks]

Magnesium has a higher nuclear charge and more delocalised electrons. There is a stronger attraction between the nucleus and delocalised electrons. Metallic bonds are stronger so more energy is required to break them.

0 5 . 2 Give an equation to show how magnesium is used as the reducing agent in the extraction of titanium.

Explain, in terms of oxidation states, why magnesium is the reducing agent.

[2 marks]

Equation

$TiCl_4 + 2Mg \rightarrow 2MgCl_2 + Ti$

Explanation Magnesium has an oxidation state of +2, which is lower than titanium (+4)

0 5 . 3 State what is observed when dilute aqueous sodium hydroxide is added to separate solutions of magnesium chloride and barium chloride.

[2 marks]

Observation with magnesium chloride white precipitate forms

Observation with barium chloride no precipitate formed

0 7 Chlorine is used to decrease the numbers of microorganisms in water.

When chlorine is added to water, there is a redox reaction, as shown by the equation

$$Cl_2 + H_2O \rightleftharpoons HClO + HCl$$

0 7 . 1 Deduce the oxidation state of chlorine in HClO and the oxidation state of chlorine in HCl

[1 mark]

Oxidation state of chlorine in $\overset{+1}{H}\overset{}{Cl}\overset{-2}{O}$ +1

Oxidation state of chlorine in $\overset{+1}{H}Cl$ -1

0 7 . 2 Give two half-equations to show the oxidation and reduction processes that occur in this redox reaction.

[2 marks]

Oxidation half-equation $^1/_2\ Cl_2 + H_2O \rightarrow HOCl + H^+ + e^-$

Reduction half-equation $^1/_2\ Cl_2 + e^- \rightarrow Cl^-$

0 1 This question is about atomic structure.

0 1 . 1 There is a general trend for an increase in ionisation energy across Period 3.
Give **one** example of an element that deviates from this trend.

Explain why this deviation occurs.

[3 marks]

Element Al

Explanation the outermost electron being removed is in the 3p orbital which is at a higher energy level than 3s orbital, so less energy is required to remove an electron from Al.

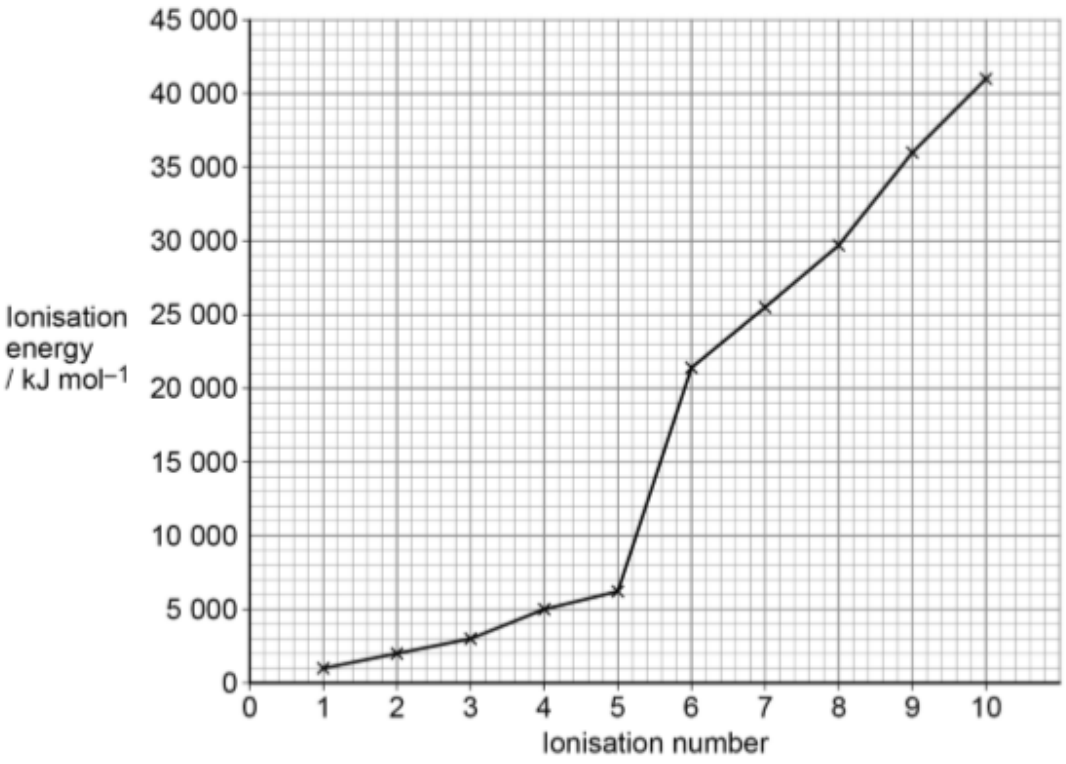
0 1 . 2 Give an equation, including state symbols, to represent the process that occurs when the **third** ionisation energy of sodium is measured.

[1 mark]

$Na^{2+}(g) \rightarrow Na^{3+}(g) + e^-$

0 1 . 3 **Figure 1** shows the successive ionisation energies of a Period 3 element, **X**.

Figure 1



Identify element **X**.
Explain your choice.

[3 marks]

Element phosphorous

Explanation There is a huge difference between 5th and 6th ionisation energies. Phosphorous have 5 electrons in the outermost shell. When the 6th electron is removed, it is removed from a shell nearer to the nucleus so there is less shielding effect and nuclear attraction to the electron is stronger. More energy is required.

0 7 . 2 Solid sodium iodide reacts with concentrated sulfuric acid to form iodine and sulfur in a redox reaction.

Give a half-equation to show the conversion of iodide ions to iodine.

Give a half-equation to show the conversion of sulfuric acid to sulfur.

Give an overall equation for this redox reaction.

Identify one other sulfur-containing reduction product formed when solid sodium iodide reacts with concentrated sulfuric acid.

[4 marks]

Half-equation for the conversion of iodide ions to iodine

$2I^- \rightarrow I_2 + 2e^-$

Half-equation for the conversion of sulfuric acid to sulfur

$H_2SO_4 + 6H^+ + 6e^- \rightarrow S + 4H_2O$

Overall equation

$6I^- + H_2SO_4 + 6H^+ \rightarrow 3I_2 + S + 4H_2O$

Other sulfur-containing reduction product

$NaHSO_4$

A student completes an experiment to determine the percentage by mass of sodium chloride in a mixture of sodium chloride and sodium iodide.

The student uses this method.

- 600 mg of the mixture are dissolved in water to form a solution.
- An excess of aqueous silver nitrate is added to the solution. This forms a precipitate containing silver chloride and silver iodide.
- Excess dilute ammonia solution is then added to the precipitate. The silver chloride dissolves.
- The silver iodide is filtered off from the solution, and is then washed and dried.

The mass of the silver iodide obtained is 315 mg

0 7 . 3 Silver nitrate is added to the solution.

Suggest why an excess is used.

To ensure that all of sodium chloride and sodium iodide has completely reacted

[1 mark]

0 7 . 4 Calculate the amount, in moles, of silver iodide obtained.

M_r(AgI) = 234.8

[1 mark]

$$\text{moles} = \frac{m}{Mr}$$

$$= \frac{0.315}{234.8}$$

$$= 1.34 \times 10^{-3} \text{ mol}$$

Amount of silver iodide 1.34×10^{-3} mol

0 7 . 5 Calculate, using your answer to Question **07.4**, the mass, in grams, of sodium iodide in the mixture.

M_r(NaI) = 149.9

[1 mark]

$NaI + AgNO_3 \rightarrow NaNO_3 + AgI$

mole ratio of NaI : AgI

1 : 1

$$\text{mass} = Mr \times n$$

$$= 149.9 \times (1.34 \times 10^{-3})$$

$$= 0.200866 \text{ g}$$

$$\simeq 0.201 \text{ g}$$

Mass of sodium iodide 0.201 g

0 7 . 6 Calculate, using your answer to Question **07.5**, the percentage by mass of sodium chloride in the mixture.

[2 marks]

$$100 - \left(\frac{0.201}{0.6} \times 100\right) = 66.5\ \%$$

Percentage of sodium chloride 66.5 %

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 = 0.5 mol of H_2 ○

B 1 g of helium atoms = 0.5 mol of He ○

C 1 dm^3 of hydrogen molecules = 1 mol of H_2 ○

D 1 dm^3 of helium atoms = 1 mol of He ○

1 0 5.0 g of an oxide of molybdenum contain 4.0 g of molybdenum.

What is the empirical formula of this oxide?

[1 mark]

O : $\frac{1}{16}$ = 0.0625 $\frac{0.0625}{0.0417}$ = 1.5

Mo : $\frac{4}{95.94}$ = 0.0417

Mo : O

1 : 1.5

2 : 3

A MoO_2 ○

B Mo_4O_5 ○

C Mo_2O_3 ○

D Mo_3O_2 ○

1 6 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. ○

15 Which equation does **not** represent a redox reaction?

[1 mark]

A $Mg + 2HCl \rightarrow MgCl_2 + H_2$ ○

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

C $Fe + CuSO_4 \rightarrow FeSO_4 + Cu$ ○

D $\overset{+2\ -2}{CuO} + 2\overset{-1}{H}\overset{+2\ -1}{Cl} \rightarrow \overset{-2}{CuCl_2} + H_2O$ ○

13 NO_2^- ions can be reduced in acidic solution to NO ($\overset{+3}{N}$ → $\overset{+2}{N}$)

How many electrons are gained when each NO_2^- ion is reduced?

[1 mark]

A 1 ○

B 2 ○

C 3 ○

D 4 ○

11 How many protons are there in 6.0 g of nitrogen gas?

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

[1 mark]

A 1.3×10^{23} ○

B 9.0×10^{23} ○

C 1.8×10^{24} ○

D 3.6×10^{24} ○

$n = \frac{6}{28}$

$= 0.214\ mol$

$0.214 \times 6.022 \times 10^{23} = 1.2887 \times 10^{23}$

$\approx 1.3 \times 10^{23}$