Q1. Which of the following contains the most chloride ions?

A 10 cm^3 of 3.30 × 10^{-2} mol dm^{-3} aluminium chloride solution ⬭

B 20 cm^3 of 5.00 × 10^{-2} mol dm^{-3} calcium chloride solution ⬭

C 30 cm^3 of 3.30 × 10^{-2} mol dm^{-3} hydrochloric acid ⬭

D 40 cm^3 of 2.50 × 10^{-2} mol dm^{-3} sodium chloride solution ⬭

(Total 1 mark)

Q2. The removal of silicon dioxide with limestone in the Blast Furnace can be represented by the following equation.

$$CaCO_3(s) + SiO_2(s) \rightarrow CaSiO_3(l) + CO_2(g)$$

The volume of carbon dioxide, measured at 298 K and 1.01 × 10^5 Pa, formed in this reaction during the removal of 1.00 tonne (1000 kg) of silicon dioxide is

A 24.5 dm^3

B 408 dm^3

C 24.5 m^3

D 408 m^3

(Total 1 mark)

Q3. The removal of silicon dioxide with limestone in the Blast Furnace can be represented by the following equation.

$$CaCO_3(s) + SiO_2(s) \rightarrow CaSiO_3(l) + CO_2(g)$$

The minimum mass of calcium carbonate needed to remove 1.00 tonne (1000 kg) of silicon dioxide is

A 0.46 tonne

B 0.60 tonne

C 1.67 tonne

D 2.18 tonne

(Total 1 mark)

Q4. Nitroglycerine, $C_3H_5N_3O_9$, is an explosive which, on detonation, decomposes rapidly to form a large number of gaseous molecules. The equation for this decomposition is given below.

$$4C_3H_5N_3O_9(l) \rightarrow 12CO_2(g) + 10H_2O(g) + 6N_2(g) + O_2(g)$$

(a) A sample of nitroglycerine was detonated and produced 0.350 g of oxygen gas.

(i) State what is meant by the term *one mole* of molecules.

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(ii) Calculate the number of moles of oxygen gas produced in this reaction, and hence deduce the total number of moles of gas formed.

Moles of oxygen gas .....

Total moles of gas .....

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(iii) Calculate the number of moles, and the mass, of nitroglycerine detonated.

Moles of nitroglycerine .....

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Mass of nitroglycerine .....

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(7)

(b) A second sample of nitroglycerine was placed in a strong sealed container and detonated. The volume of this container was 1.00×10^{-3} m^3. The resulting decomposition produced a total of 0.873 mol of gaseous products at a temperature

of 1100 K.

State the ideal gas equation and use it to calculate the pressure in the container after detonation.

(The gas constant R = 8.31 J $K^{-1}mol^{-1}$)

Ideal gas equation .....

Pressure .....

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(4)
(Total 11 marks)

Q5. CCl_4 is an effective fire extinguisher but it is no longer used because of its toxicity and its role in the depletion of the ozone layer. In the upper atmosphere, a bond in CCl_4 breaks and reactive species are formed.

(a) Identify the condition that causes a bond in CCl_4 to break in the upper atmosphere. Deduce an equation for the formation of the reactive species.

Condition .....

Equation

.....

(2)

(b) One of the reactive species formed from CCl_4 acts as a catalyst in the decomposition of ozone.

Write **two** equations to show how this species acts as a catalyst.

Equation 1

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Equation 2

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(2)

(c) A small amount of the freon CF_3Cl with a mass of 1.78×10^{-4} kg escaped from a refrigerator, into a room of volume 100 m^3. Assuming that the freon is evenly distributed throughout the air in the room, calculate the number of freon molecules in a volume of 500 cm^3.
Give your answer to the appropriate number of significant figures.

The Avogadro constant = 6.02×10^{23} mol^{-1}.

Number of molecules = ...

(3)
(Total 7 marks)

Q6. Norgessaltpeter was the first nitrogen fertiliser to be manufactured in Norway. It has the formula $Ca(NO_3)_2$

(a) Norgessaltpeter can be made by the reaction of calcium carbonate with dilute nitric acid as shown by the following equation.

$$CaCO_3(s) + 2HNO_3(aq) \longrightarrow Ca(NO_3)_2(aq) + CO_2(g) + H_2O(l)$$

In an experiment, an excess of powdered calcium carbonate was added to 36.2 cm^3 of 0.586 mol dm^{-3} nitric acid.

(i) Calculate the amount, in moles, of HNO_3 in 36.2 cm^3 of 0.586 mol dm^{-3} nitric acid. Give your answer to 3 significant figures.

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(1)

(ii) Calculate the amount, in moles, of $CaCO_3$ that reacted with the nitric acid. Give your answer to 3 significant figures.

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(1)

(iii) Calculate the minimum mass of powdered $CaCO_3$ that should be added to react with all of the nitric acid.

Give your answer to 3 significant figures.

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(2)

(iv) State the type of reaction that occurs when calcium carbonate reacts with nitric acid.

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(1)

(b) Norgessaltpeter decomposes on heating as shown by the following equation.

$$2Ca(NO_3)_2(s) \longrightarrow 2CaO(s) + 4NO_2(g) + O_2(g)$$

A sample of Norgessaltpeter was decomposed completely.

The gases produced occupied a volume of 3.50×10^{-3} m^3 at a pressure of 100 kPa and a temperature of 31 °C.
(The gas constant R = 8.31 J K^{-1} mol^{-1})

(i) Calculate the total amount, in moles, of gases produced.

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(3)

(ii) Hence calculate the amount, in moles, of oxygen produced.

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(1)

(c) Hydrated calcium nitrate can be represented by the formula $Ca(NO_3)_2.xH_2O$ where x is an integer.

A 6.04 g sample of $Ca(NO_3)_2.xH_2O$ contains 1.84 g of water of crystallisation.

Use this information to calculate a value for x.
Show your working.

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(3)
(Total 12 marks)

Q7. In an experiment to identify a Group 2 metal (X), 0.102 g of X reacts with an excess of aqueous hydrochloric acid according to the following equation.

$$X + 2HCl \longrightarrow XCl_2 + H_2$$

The volume of hydrogen gas given off is 65 cm^3 at 99 kPa pressure and 303 K.
The gas constant is R = 8.31 $J\ K^{-1}\ mol^{-1}$.

Which is X?

A Barium ⬭

B Calcium ⬭

C Magnesium ⬭

D Strontium ⬭

(Total 1 mark)

Q8. Zinc forms many different salts including zinc sulfate, zinc chloride and zinc fluoride.

(a) People who have a zinc deficiency can take hydrated zinc sulfate ($ZnSO_4.xH_2O$) as a dietary supplement.

A student heated 4.38 g of hydrated zinc sulfate and obtained 2.46 g of anhydrous zinc sulfate.

Use these data to calculate the value of the integer x in $ZnSO_4.xH_2O$
Show your working.

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(3)

(b) Zinc chloride can be prepared in the laboratory by the reaction between zinc oxide and hydrochloric acid.
The equation for the reaction is

$$ZnO + 2HCl \longrightarrow ZnCl_2 + H_2O$$

A 0.0830 mol sample of pure zinc oxide was added to 100 cm^3 of 1.20 mol dm^{-3} hydrochloric acid.

Calculate the maximum mass of anhydrous zinc chloride that could be obtained from the products of this reaction.

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(4)

(c) Zinc chloride can also be prepared in the laboratory by the reaction between zinc and hydrogen chloride gas.

$$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$$

An impure sample of zinc powder with a mass of 5.68 g was reacted with hydrogen chloride gas until the reaction was complete. The zinc chloride produced had a mass of 10.7 g.

Calculate the percentage purity of the zinc metal.
Give your answer to 3 significant figures.

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(4)

(d) Predict the type of crystal structure in solid zinc fluoride and explain why its melting point is high.

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(3)
(Total 14 marks)