1 Chemicals called 'acids' have been known throughout history. The word acid comes from the Latin 'acidus' meaning sour. Dilute sulfuric acid, H_2SO_4, is a common laboratory acid.

(a) (i) State the formulae of two ions released when sulfuric acid is in aqueous solution.

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

(ii) A student adds a sample of solid potassium carbonate, K_2CO_3, to an excess of dilute sulfuric acid.

Describe what the student would **see** and write the equation for the reaction which takes place.

.....

.....

.....

.....

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

(b) Dilute sulfuric acid reacts with alkalis such as sodium hydroxide.

Solid sodium hydroxide is known as caustic soda. It has a household use as a drain cleaner.

A student believes a box of caustic soda has been accidentally contaminated.

- To prove this, the student dissolves 2.00 g of the impure caustic soda in water and the solution is made up to 250 cm^3.
- 25.0 cm^3 of this solution of caustic soda is neutralised by 24.60 cm^3 of 0.100 mol dm^{-3} dilute sulfuric acid.

$$H_2SO_4(aq) + 2NaOH(aq) \longrightarrow Na_2SO_4(aq) + 2H_2O(l)$$

(i) Calculate the amount, in moles, of H_2SO_4 used.

answer = ... mol **[1]**

(ii) Determine the amount, in moles, of NaOH in the 25.0 cm^3 used.

answer = ... mol **[1]**

(iii) Calculate the percentage, by mass, of NaOH in the impure caustic soda.

answer = ... **[3]**

[Total: 10]

2 In an atom the electrons occupy sub-shells in order of increasing energy.

(a) Complete the table below to show the order in which the next two sub-shells are filled.

1s	2s	2p	3s	3p	4s		

increasing energy $\rightarrow$

[1]

(b) Sub-shells are made up of orbitals.

(i) What is meant by an *orbital*?

.....

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

(ii) State the total number of electrons occupying the p orbitals in one chlorine atom.

answer = ... **[1]**

(c) How many electrons are there in one ion of Ca^{2+}?

answer = ... **[1]**

(d) The successive ionisation energies of aluminium are shown in the table below. Some of these ionisations involve the removal of an electron from an s sub-shell.

ionisation energy / kJ mol^{-1}	578	1817	2745	11 578	14 831	18 378	23 296	27 460	31 862	38 458	42 655
ionisation number	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th

(i) State **all** the ionisation numbers that involve the removal of an electron from s sub-shells.

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

(ii) Write the equation that represents the third ionisation energy of A*l*.
Include state symbols.

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

[Total: 8]

3 The Group 2 element magnesium was first isolated by Sir Humphry Davy in 1808.

(a) Magnesium has three stable isotopes, which are ^{24}Mg, ^{25}Mg and ^{26}Mg.

(i) Complete the table below to show the atomic structures of ^{24}Mg and ^{25}Mg.

	protons	**neutrons**	**electrons**
^{24}Mg			
^{25}Mg			

[2]

(ii) A sample of magnesium contained ^{24}Mg: 78.60%; ^{25}Mg: 10.11%; ^{26}Mg: 11.29%.

Calculate the relative atomic mass of this sample of Mg.

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

answer = ... **[2]**

(iii) Define the term *relative atomic mass*.

.....

.....

.....

.....

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

(b) The reaction between magnesium and sulfuric acid is a redox reaction.

$$Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2(g)$$

(i) Use oxidation numbers to identify which element has been oxidised.

Explain your answer.

element oxidised .....

explanation .....

.....

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

(ii) Describe what you would **see** when magnesium reacts with an excess of sulfuric acid.

.....

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

(c) Epsom salts can be used as bath salts to help relieve aches and pains.

Epsom salts are crystals of hydrated magnesium sulfate, $MgSO_4 \cdot xH_2O$.

A sample of Epsom salts was heated to remove the water. 1.57 g of water was removed leaving behind 1.51 g of anhydrous $MgSO_4$.

(i) Calculate the amount, in mol, of anhydrous $MgSO_4$ formed.

amount = ... mol **[2]**

(ii) Calculate the amount, in mol, of H_2O removed.

amount = ... mol **[1]**

(iii) Calculate the value of x in $MgSO_4 \cdot xH_2O$.

x = ... **[1]**

[Total: 15]

4 Calcium carbonate, $CaCO_3$, reacts with hydrochloric acid as shown in the equation below.

$$CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

(a) 7.50×10^{-3} mol $CaCO_3$ reacts with 0.200 mol dm^{-3} HCl.

(i) Calculate the volume, in cm^3, of 0.200 mol dm^{-3} HCl required to react with 7.50×10^{-3} mol $CaCO_3$.

answer = ... cm^3 **[2]**

(ii) Calculate the volume, in cm^3, of CO_2 formed at room temperature and pressure.

answer = ... cm^3 **[1]**

(b) When heated strongly, $CaCO_3$ decomposes.

Write an equation, including state symbols, for the thermal decomposition of $CaCO_3$.

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

(c) Calcium oxide reacts with water and with nitric acid.

State the formula of the calcium compound formed when:

(i) calcium oxide reacts with water, ... **[1]**

(ii) calcium oxide reacts with nitric acid. ..... **[1]**

[Total: 7]

5 This question is about iodine and its compounds.

(a) Iodine has a stable isotope with a relative isotopic mass of 127.

In 1986, a radioactive isotope of iodine, with a relative isotopic mass of 131, was released into the atmosphere following an explosion at a nuclear power plant in Chernobyl.

(i) Define the term *relative isotopic mass*.

.....

.....

.....

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

(ii) Complete the table to show the number of sub-atomic particles in an atom of iodine-127 and in an atom of iodine-131.

	protons	**neutrons**	**electrons**
iodine-127			53
iodine-131			53

[1]

(b) In the human body, iodide ions, I^-, are necessary for the thyroid gland to function correctly. Some countries add potassium iodide, KI, to table salt as a source of iodide ions.

The Guideline Daily Amount, GDA, of iodide ions is 70.0 µg (1 µg = 1×10^{-6} g).

(i) Calculate the mass of KI, in µg, that would be needed to supply the GDA of iodide ions.

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

answer = ... µg **[2]**

(ii) Apart from reasons of cost, suggest why some countries do **not** add KI to table salt.

.....

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

(c) When chlorine gas is bubbled through aqueous potassium iodide, a reaction takes place.

(i) Write the ionic equation for this reaction.

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

(ii) At room temperature, chlorine is a gas and iodine is a solid. When heated together, chlorine reacts with iodine to form iodine monochloride, IC*l*.

IC*l* has a higher boiling point than Cl_2.

Explain, in terms of the intermolecular forces present, why IC*l* has a higher boiling point than Cl_2.

In your answer, you should use appropriate technical terms spelled correctly.

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.....

.....

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

[Total: 9]

6 Calcium chloride, $CaCl_2$, can be made by different reactions.

A student prepared hydrated calcium chloride by carrying out the following experiment.

Step 1 The student added an excess of a solid calcium compound, **X**, to dilute hydrochloric acid. The mixture fizzed as the solid reacted.

Step 2 The student filtered the mixture to give an aqueous solution of $CaCl_2$.

Step 3 On evaporation, colourless crystals of hydrated calcium chloride were formed.

(a) Describe a chemical test which the student could have carried out to prove that the filtrate contains aqueous chloride ions.

.....

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

(b) A friend of the student suggested that solid **X** was calcium oxide.

State **one** reason why the student's friend was **incorrect** and suggest a possible identity of solid **X**.

reason: .....

.....

solid **X**: ..... **[2]**

(c) Hydrated calcium chloride has a molar mass of $219.1\,g\,mol^{-1}$.

(i) What is meant by the term *hydrated* calcium chloride?

.....

.....

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

(ii) Determine the formula of the **hydrated** calcium chloride.

You **must** show your working.

formula = ... **[2]**

(d) Calcium chloride can also be formed by directly reacting calcium with chlorine gas.

Draw a '*dot-and-cross*' diagram to show the bonding in calcium chloride.

Show outer electrons only.

[2]

(e) The student decided to prepare barium bromide, $BaBr_2$, by directly reacting barium with bromine gas.

The student was unsure whether this preparation would be more reactive or less reactive than the preparation of $CaCl_2$ in **(d)**.

Explain why the student was unsure of the relative reactivity of the two preparations.

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.....

.....

.....

.....

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

[Total: 11]