**1.** (a) Cobalt has only one naturally occurring type of atom, $^{59}_{27}Co$, but the isotope $^{60}_{27}Co$ can be made artificially.

(i) Define the term *atomic number*

……..……

**(1)**

(ii) What is the difference between the atomic structures of $^{59}_{27}Co$ and $^{60}_{27}Co$?

……..……

**(1)**

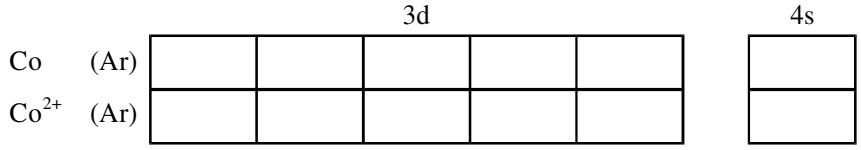
(iii) Why do both isotopes have the same chemical reactions?

……..……

……..……

**(1)**

(b) Give the electronic configuration of a cobalt atom and a $Co^{2+}$ ion.




**(2)**

(c) Cobalt can be described both as a *d*–block element and as a transition element.

State what is meant by each of the terms.

(i) *d*–block element ……

……..……

……..……

**(1)**

(ii) Transition element ……..

……..……

……..……

**(1)**

(d) In aqueous solution water combines with the $Co^{2+}$ ion to form the complex ion $[Co(H_2O)_6]^{2+}$ which gives a pink colour to the solution.

(i) What feature of the water molecule allows it to form a complex ion with $Co^{2+}$?

……..……

**(1)**

(ii) What types of bond are present in the complex ion $[Co(H_2O)_6]^{2+}$?

……..……

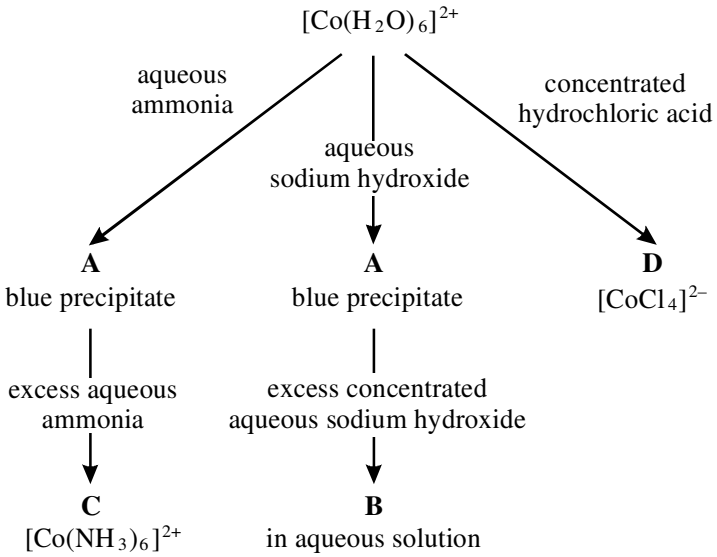
**(2)**

(iii) Suggest the shape of the ion $[Co(H_2O)_6]^{2+}$.

……..……

**(1)**

(e) Consider the following reactions




(i) Give the name of the blue precipitate, **A**, and write an ionic equation for its formation from $[Co(H_2O)_6]^{2+}$.

……..……

……..……

**(2)**

(ii) What name is given to the type of reaction occurring in (i)?

……..……

**(1)**

(iii) Suggest a formula for the cobalt complex ion **B** present in the solution.

……..……

**(1)**

(iv) Write an equation for the formation of ion **D** from $[Co(H_2O)_6]^{2+}$ and suggest the type of reaction taking place.

……..……

……..……

**(2)**

**(Total 17 marks)**

**2.** (a) Write balanced equations for the reactions of sodium, chlorine and phosphorus(III) oxide with water. In each case suggest a likely pH of the solution formed.

(i) Sodium with water.

……..……

pH …….

**(2)**

(ii) Chlorine with water.

……..……

pH …….

**(2)**

(iii) Phosphorus(III) oxide with water.

……..……

pH …….

**(2)**

(b) From the oxides of the elements in Period 3 (sodium to chlorine), give the formula of one oxide with

(i) a simple molecular structure;

……

**(1)**

(ii) an ionic structure.

……

**(1)**

(c) (i) Aluminium oxide is an amphoteric oxide. State the meaning of the term **amphoteric**.

……

**(1)**

(ii) Write two ionic equations which illustrate the amphoteric behaviour of aluminium oxide.

……

……

**(2)**

(d) (i) Give an equation to represent one reaction, other than direct combination of the elements, for the formation of magnesium oxide.

……

……

**(2)**

(ii) Would a method similar to that used in (i) be suitable for obtaining sodium oxide? Give a reason to support your answer.

……

……

**(2)**

(iii) When magnesium oxide is shaken with water the resulting solution has a pH of 9. Explain this result.

……

……

……

**(2)**

(e) In addition to the normal oxide, sodium forms a peroxide, $Na_2O_2$. This reacts with carbon dioxide to form sodium carbonate and oxygen:

$$2Na_2O_2 + 2CO_2 \rightarrow 2Na_2CO_3 + O_2$$

(i) Calculate the volume of oxygen gas that would be formed by the reaction of 0.39 g of sodium peroxide with excess carbon dioxide.

(The molar volume of a gas at the temperature and pressure of the reaction should be taken as 24 $dm^3$.)

**(3)**

(ii) How many molecules of oxygen would be present in this volume of oxygen?

(The Avogadro constant, $L$, is $6.02 \times 10^{23}$ $mol^{-1}$.)

**(1)**

(iii) Use oxidation numbers to identify the type of process that occurs in the formation of oxygen from the peroxide ion.

……

……

……

**(2)**

**(Total 23 marks)**

**3.** (a) Describe the bonding present in solid aluminium. Explain why aluminium is a conductor of electricity.

……

……

……

……

……

**(4)**

(b) Aluminium combines readily with both dry fluorine and dry chlorine. Anhydrous aluminium chloride is a white solid which sublimes at about 200 ºC; it reacts with water and dissolves in non–polar solvents. Aluminium fluoride is a crystalline solid up to a temperature in excess of 1290 ºC; it is insoluble in non–polar solvents.

(i) Suggest, using the information above, the name of the bond type present in:

anhydrous aluminium chloride;

……

anhydrous aluminium fluoride.

……

**(2)**

(ii) Give an explanation for the difference in bond type present in the two anhydrous aluminium halides.

……

……

……

……

**(3)**

(iii) Explain why the bonding in anhydrous aluminium fluoride leads to a high melting temperature.

……

……

**(1)**

(c) The purity of a sample of anhydrous aluminium chloride can be found by dissolving a known mass in water and reacting the solution formed with aqueous silver nitrate. The reaction between aluminium chloride and water may be represented by the equation

$AlCl_3 + 6H_2O \rightarrow [Al(OH)_4(H_2O)_2]^- + 4H^+ + 3Cl^-$ $\Delta H$ is negative

(i) The chloride ions released then react with silver ions to form silver chloride, AgCl. Write an ionic equation for the formation of the precipitate of silver chloride.

……

**(1)**

(ii) 0.750 g of aluminium chloride were dissolved in distilled water and the solution made up to 250 $cm^3$. 25.0 $cm^3$ portions of this solution completely react with 24.0 $cm^3$ of 0.0500 mol $dm^{-3}$ silver nitrate solution.

Calculate the percentage purity of the aluminium chloride used.

**(4)**

(iii) Suggest two reasons why the method used in (ii) can result in a low value for the purity.

……

……

**(2)**

**(Total 17 marks)**