1 Nickel is an element in the d-block of the Periodic Table.

(a) Complete the electronic configuration of a nickel atom using the s, p, d notation.

(1)

$1s^2$ .....

(b) A sample of nickel is made up of three isotopes. The percentage abundances are shown in the table below.

Isotope	Percentage abundance
^{58}Ni	69.02
^{60}Ni	27.32
^{62}Ni	3.66

Calculate the relative atomic mass of nickel. Give your answer to **two** decimal places.

(2)

(c) Nickel reacts with carbon monoxide, CO, to give the compound nickel carbonyl, $Ni(CO)_4$.

$$Ni(s) + 4CO(g) \rightarrow Ni(CO)_4(g)$$

(i) Calculate the volume of carbon monoxide, in dm^3, measured at room temperature and pressure, that is required to react completely with 5.87 g of nickel.

[Relative atomic mass: Ni = 58.7
Molar volume of a gas = 24 dm^3 mol^{-1} at room temperature and pressure.]

(3)

(ii) Calculate the **number** of carbon monoxide molecules present in the volume of gas you have calculated in (c)(i).

[The Avogadro constant, $L = 6.02 \times 10^{23}$ mol^{-1}]

(1)

(d) Nickel(II) nitrate, $Ni(NO_3)_2$, can be made by several different methods.

Method 1

Nickel(II) oxide, NiO, was reacted with dilute nitric acid according to the equation

$$NiO(s) + 2HNO_3(aq) \rightarrow Ni(NO_3)_2(aq) + H_2O(l)$$

(i) Calculate the volume of 2.00 mol dm^{-3} dilute nitric acid, in cm^3, that was required to exactly neutralize 1.494 g of nickel(II) oxide.

Use the relative atomic masses: Ni = 58.7, O = 16.0

(3)

Method 2

A volume of 25.0 cm^3 of 2.00 mol dm^{-3} nitric acid, HNO_3, was transferred to a beaker. Solid nickel(II) carbonate, $NiCO_3$, was added until it was in excess.

(ii) Why was **excess** nickel(II) carbonate used?

(1)

.....

.....

(iii) Why must the beaker be **much** larger than the volume of acid used?

(1)

.....

.....

.....

(iv) Write a balanced equation for the reaction between nickel(II) carbonate and dilute nitric acid, including state symbols.

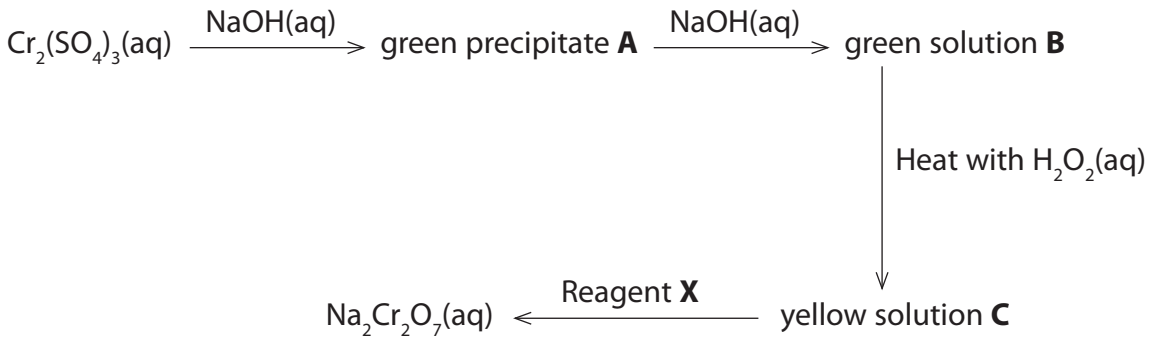
(2)

***(v)** For **Method 2**, describe the practical steps that you would take to obtain pure dry crystals of hydrated nickel(II) nitrate, $Ni(NO_3)_2.6H_2O$, from a mixture of nickel(II) nitrate solution and unreacted solid nickel(II) carbonate.

(4)

(Total for Question = 18 marks)

2 Sodium dichromate(VI) may be prepared from chromium(III) sulfate using the sequence outlined below.



(a) (i) Complete the table below, giving the **formula** of the chromium containing species.

(4)

Substance	**Formula of chromium containing species**
$Cr_2(SO_4)_3(aq)$	
Green precipitate **A**	
Green solution **B**	
Yellow solution **C**	

(ii) Complete the half equation for the reduction of hydrogen peroxide, $H_2O_2(aq)$.

(1)

$$H_2O_2 + \text{.....} \rightarrow \text{.....} OH$$

(iii) Identify reagent **X**

(1)

(iv) Write an **ionic** equation for the conversion of solution **C** to $Na_2Cr_2O_7$. State symbols are not required.

(1)

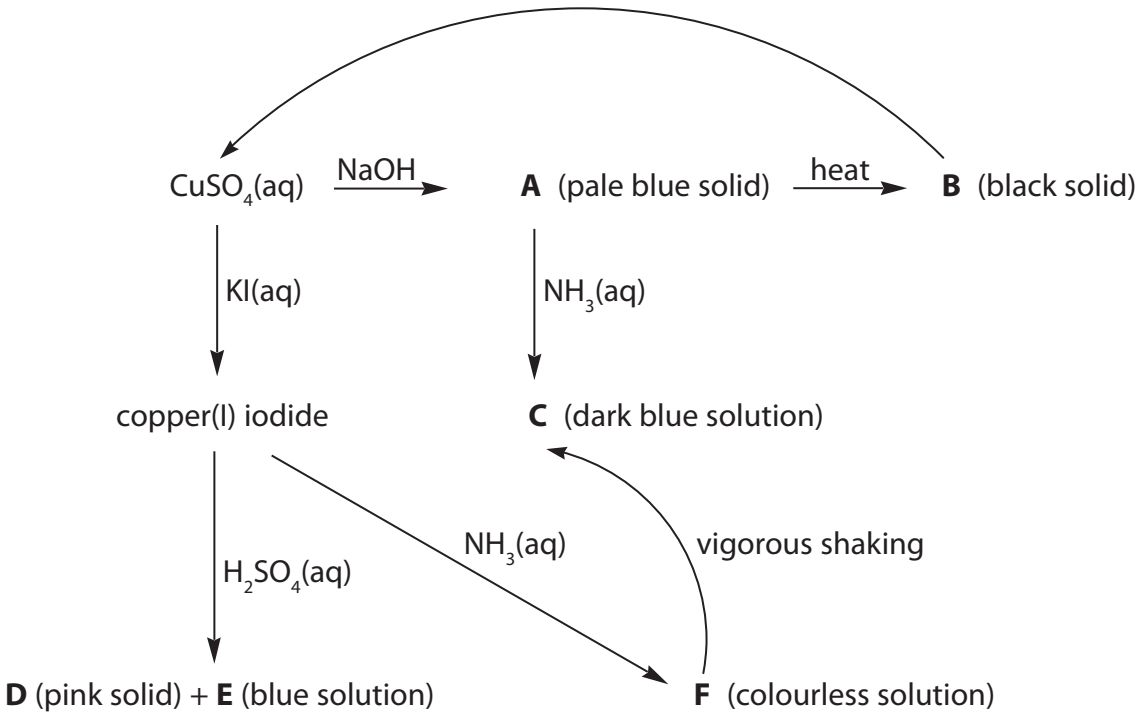
(b) Chromium also exists in a +2 oxidation state. Use the Data booklet to determine the feasibility of the disproportionation of chromium(III) in aqueous solution into chromium(II) and dichromate(VI).

In your answer, show both half equations and the overall equation for the proposed disproportionation. Calculate $E^{\ominus}_{cell}$ for this reaction and use this value to predict the feasibility of this reaction.

(4)

(Total for Question = 11 marks)

3 This question concerns the chemistry of copper. In the sequence below, **A**, **B**, **C**, **D**, **E** and **F** all contain copper in various oxidation states.



(a) Identify, by name (including the oxidation state where appropriate) or formula, the copper-containing species in the sequence.

(6)

A .....

B .....

C .....

D .....

E .....

F .....

(b) Identify, by name or formula, the reagent that would be used to convert **B** into $CuSO_4(aq)$.

(1)

.....

(c) (i) **C** and **F** are the same type of chemical species. Name this type.

(1)

.....

(ii) Explain why **C** is coloured but **F** is colourless.

(3)

.....

.....

.....

.....

.....

.....

*(iii) Explain why **F** changes into **C** on shaking.

(2)

.....

.....

.....

.....

.....

(d) The reaction of copper(I) iodide to form **D** and **E** is a disproportionation.

(i) Explain the term disproportionation.

(2)

.....

.....

.....

.....

(ii) Write an ionic equation for this reaction. State symbols are **not** required.

(1)

(iii) Use the relevant standard reduction (electrode) potentials, from the table on page 17 of your data booklet, to calculate the $E^{\ominus}_{cell}$ value for this reaction, giving your answer with the appropriate sign.

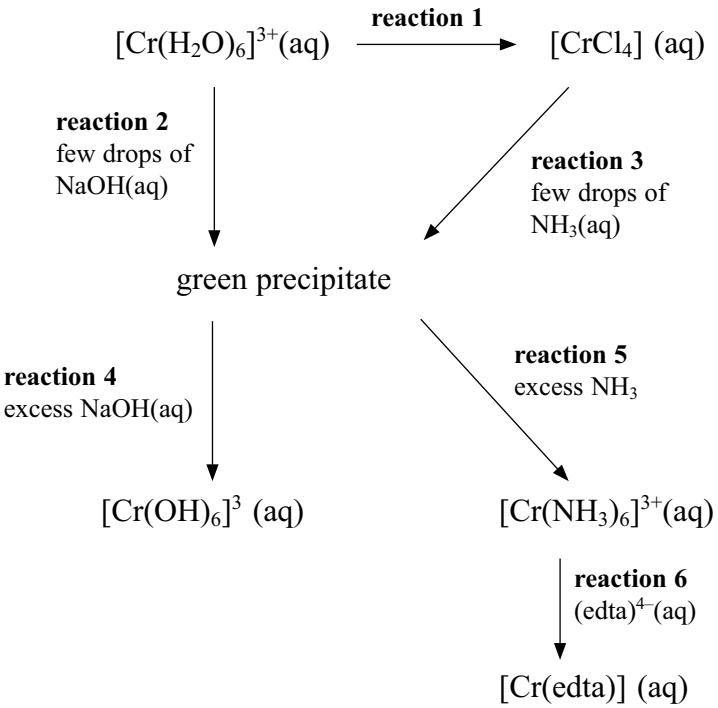
(2)

*(iv) If copper(I) iodide is treated with nitric acid, rather than sulfuric acid, a blue solution is still formed but no pink solid. Use the standard electrode potentials on page 15 of your data booklet to explain this. Quote any data that you use.

(4)

(Total for Question = 22 marks)

4 The reaction scheme below summarises some of the reactions of chromium ions in aqueous solution. Look carefully at the scheme and answer the questions that follow.



(a) (i) Explain why the $[Cr(H_2O)_6]^{3+}$ ion is coloured.

(3)

.....

.....

.....

.....

.....

.....

(ii) Suggest what reagent is needed for **reaction 1** and identify the type of reaction.

(2)

.....

.....

(b) (i) $[Cr(H_2O)_6]^{3+}$ ions react with water to form an acidic solution. Complete the equation for this reaction.

(2)

$[Cr(H_2O)_6]^{3+}(aq) + H_2O(l) \rightleftharpoons$ ..... + ...

(ii) The pH of an aqueous solution of $[Cu(H_2O)_6]^{2+}$ is higher than that of an aqueous solution of $[Cr(H_2O)_6]^{3+}$ of the same concentration. Suggest why this is so.

(2)

.....

.....

.....

(c) Give the formula of the green precipitate formed in **reactions 2 and 3**.

(1)

.....

(d) By considering the nature of the reactants in **reaction 4**, explain why the green precipitate reacts as shown in the scheme. Suggest how you could reverse **reaction 4**.

(3)

.....

.....

.....

.....

.....

.....

(e) Write the equation for **reaction 6** and use this to explain, in terms of the entropy change, why the complex $[Cr(edta)]^-$ is relatively more stable than $[Cr(NH_3)_6]^{3+}$.

(2)

Equation

.....

.....

.....

.....

(Total for Question 15 marks)