Oxford Cambridge and RSA

A level Chemistry A

H432/01 Periodic table, elements and physical chemistry

Question Set 17

1. (a) (i) This question is about reactions of ions and compounds of transition elements.

A student carries out two experiments on a solution containing $[Cr(H_2O)_6]^{3+}(aq)$.

Experiment 1
The student adds an excess of aqueous ammonia to a solution containing $[Cr(H_2O)_6]^{3+}(aq)$until a purple solution is formed.

Experiment 2
The student carries out the following reaction sequence.

Step 1 NaOH(aq) is added slowly to a solution containing $[Cr(H_2O)_6]^{3+}(aq)$ in a boiling tube.
A grey–green precipitate forms.

Step 2 An excess of NaOH(aq) is added to the boiling tube.
The precipitate dissolves and a green solution forms containing a 6 coordinate complex ion.

Step 3 H_2O_2 is added to the mixture and the boiling tube is heated.
A yellow solution forms.

Step 4 The solution in the boiling tube is acidified.
The solution now contains $Cr_2O_7^{2-}(aq)$.

What is the formula of the complex ion in the purple solution that forms in **Experiment 1**?

[1]

(ii) Suggest an equation for the reaction in **Experiment 2**, **Step 1**.Include state symbols.

[1]

(iii) Draw a 3-D diagram for the shape of the complex ion that forms in **Experiment 2**, **Step 2**.Include the charge of the ion.

[ ] .....

[2]

(iv) What is the formula of the **ion** that causes the yellow colour in **Experiment 2**, **Step 3**?

[1]

(v) State the colour of the solution that forms in **Experiment 2**, **Step 4**.

[1]

(b) (i) Vanadium ions have four common oxidation states. **Table 1.1** shows the colours of the ionsin aqueous solution.

Oxidation state of vanadium	Vanadium ion	Colour
+5	$VO_2^+(aq)$	yellow
+4	$VO^{2+}(aq)$	blue
+3	$V^{3+}(aq)$	green
+2	$V^{2+}(aq)$	violet

Table 1.1

Complete the electron configuration of a V^{3+} ion.

$1s^2$……

[1]

(ii) The student adds excess iron to a solution containing $VO^{2+}(aq)$ ions, and observes thatthe colour of the solution changes from blue to green and then to violet.

Use the relevant standard electrode potentials shown in **Table 1.2** to explain theseobservations.

[3]

	Redox system	$E^{\ominus}$/V
1	$V^{2+}(aq) + 2e^- \rightleftharpoons V(s)$	−1.18
2	$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)$	−0.44
3	$V^{3+}(aq) + e^- \rightleftharpoons V^{2+}(aq)$	−0.26
4	$VO^{2+}(aq) + 2H^+ + e^- \rightleftharpoons V^{3+}(aq) + H_2O(l)$	+0.34
5	$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	+0.77
6	$VO_2^+(aq) + 2H^+ + e^- \rightleftharpoons VO^{2+}(aq) + H_2O(l)$	+1.00

Table 1.2

(iii) Construct an equation for the **first** colour change from blue to green.

[1]

(c) (i) Iron(II) gluconate, $C_{12}H_{22}FeO_{14}$, is the active ingredient in some brands of iron supplements.

A student carries out an experiment to determine the mass of iron(II) gluconate in one tabletof an iron supplement, using the method below.

Stage 1 The student crushes two tablets and dissolves the powdered tablets in dilutesulfuric acid.

Stage 2 The student makes up the solution from **Stage 1** to 250.0 cm^3 in a volumetric flask.

Stage 3 The student then titrates 25.0 cm^3 portions of the solution obtained in **Stage 2** with0.00200 mol dm^{-3} potassium manganate(VII).

The student obtains a mean titre of 13.50 cm^3.

In this titration, 1 mol of manganate(VII) ions reacts with 5 mol of iron(II) ions.

Explain why the student used 0.00200 mol dm^{-3} potassium manganate(VII) solution for this titration, rather than the more usual concentration of 0.0200 mol dm^{-3} used in manganate(VII) titrations. **[1]**

(ii) Use the student's results to determine the mass, in mg, of iron(II) gluconate in **one** tablet.

Give your answer to **3** significant figures.

mass of iron(II) gluconate in one tablet = …… mg **[5]**

(iii) Some iron supplements contain iron(II) sulfate or iron(II) fumarate.

The information in **Table 1.3** is taken from the labels of two iron supplements, **A** and **B**.

Iron supplement	Iron compound	Mass of iron compound i one tablet/mg
A	iron(II) sulfate, $FeSO_4$	180
B	iron(II) fumarate, $C_4H_2FeO_4$	210

Table 1.3

Choose which iron supplement, **A** or **B**, would provide the greater mass of iron per tablet.
iron supplement: **[1]**

Total Marks for Question Set 17: 18