

**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  $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}(\text{aq})$ .

**Experiment 1**

The student adds an excess of aqueous ammonia to a solution containing  $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}(\text{aq})$  until a purple solution is formed.

**Experiment 2**

The student carries out the following reaction sequence.

- Step 1**  $\text{NaOH}(\text{aq})$  is added slowly to a solution containing  $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}(\text{aq})$  in a boiling tube.  
A grey-green precipitate forms.
- Step 2** An excess of  $\text{NaOH}(\text{aq})$  is added to the boiling tube.  
The precipitate dissolves and a green solution forms containing a 6 coordinate complex ion.
- Step 3**  $\text{H}_2\text{O}_2$  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  $\text{Cr}_2\text{O}_7^{2-}(\text{aq})$ .

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 ions in aqueous solution.

Oxidation state of vanadium	Vanadium ion	Colour
+5	$\text{VO}_2^+(\text{aq})$	yellow
+4	$\text{VO}^{2+}(\text{aq})$	blue
+3	$\text{V}^{3+}(\text{aq})$	green
+2	$\text{V}^{2+}(\text{aq})$	violet

**Table 1.1**

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

$1s^2$ .....

[1]

(ii) The student adds excess iron to a solution containing  $\text{VO}^{2+}(\text{aq})$  ions, and observes that the 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 these observations.

[3]

Redox system			$E^\circ/V$
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 tablet of an iron supplement, using the method below.

**Stage 1** The student crushes two tablets and dissolves the powdered tablets in dilute sulfuric acid.

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

**Stage 3** The student then titrates  $25.0\text{ cm}^3$  portions of the solution obtained in **Stage 2** with  $0.00200\text{ mol dm}^{-3}$  potassium manganate(VII).

The student obtains a mean titre of  $13.50\text{ cm}^3$ .

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

Explain why the student used  $0.00200\text{ mol dm}^{-3}$  potassium manganate(VII) solution for this titration, rather than the more usual concentration of  $0.0200\text{ mol dm}^{-3}$  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
<b>A</b>	iron(II) sulfate, $\text{FeSO}_4$	180
<b>B</b>	iron(II) fumarate, $\text{C}_4\text{H}_2\text{FeO}_4$	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**

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