Oxford Cambridge and RSA

A Level Chemistry B (Salters)

H433/02 Scientific literacy in chemistry

Question Set 4

1 Chromium is a metal with many uses, one of which is the production of a shiny chromium platingon steel.

Chromium is made from its ore chromite, $FeCr_2O_4$, by the following reactions. Iron has one of its common oxidation states in chromite.

$4FeCr_2O_4 + 8Na_2CO_3 + 7O_2 \rightarrow 8Na_2CrO_4 + 2Fe_2O_3 + 8CO_2$ **equation 4.1**

$2Na_2CrO_4 + H_2SO_4 \rightarrow Na_2Cr_2O_7 + Na_2SO_4 + H_2O$ **equation 4.2**

$Na_2Cr_2O_7 + 2C \rightarrow Cr_2O_3 + Na_2CO_3 + CO$ **equation 4.3**

$Cr_2O_3 + 2Al \rightarrow Al_2O_3 + 2Cr$ **equation 4.4**

(a) **(i)** Complete the table below showing the oxidation states of chromium species in the equations above.

For each equation state whether chromium has been reduced, oxidised or neither.

Equation no.	Oxidation state ofCr in reactant	Oxidation state ofCr in product	Has Cr been oxidised, reduced or neither?
4.1			
4.2			
4.3			
4.4			

[4]

(ii) Calculate the maximum mass of chromium (in kg) that could be obtained from 1000 g of chromite.

mass = kg **[2]**

(b) **(i)** Chromium plating is carried out using a solution of chromium(III) chloride with a graphite anode.

Write the electron configuration of a Cr^{3+} ion, using sub-shells and atomic orbitals. **[1]**

(ii) Draw a labelled diagram of a simple apparatus to carry out chromium plating of a steel object in a student laboratory. **[3]**

(iii) Write a half-equation for the cathode reaction in the cell in **(b)(ii)**. **[1]**

(iv) A 'mole of electrons' is 96 500 coulombs and a coulomb is a current of 1 amp flowing for 1 second.

Calculate the time (in hours) needed to deposit 26 g of chromium at a current of 5.0 amps in the cell in **(b)(ii)**.

time = hours **[3]**

(c) **(i)** In a solution of chromium(III) chloride an equilibrium exists, as shown in **equation 4.5**.

$$[CrCl_2(H_2O)_4]^+ + 2H_2O \rightleftharpoons [Cr(H_2O)_6]^{3+} + 2Cl^-$$

green violet **equation 4.5**

Name the ligands in the green complex. **[1]**

(ii) Some students have a violet solution of chromium(III) chloride.

Use your knowledge of equilibria to suggest and explain how they might make the violet solution turn green.

Give the **name** of any reagent required. **[2]**

(d) **(i)** The concentration of an ethanol solution can be measured using the following steps.

- add excess acidified dichromate, $Cr_2O_7^{2-}$, some of which reacts with the ethanol.
- add excess iodide that reacts with the remaining dichromate.
- titrate the iodine produced with sodium thiosulfate.

$$3C_2H_5OH + 2Cr_2O_7^{2-} + 16H^+ \rightarrow 3CH_3COOH + 4Cr^{3+} + 11H_2O \quad \textbf{equation 4.6}$$

$$Cr_2O_7^{2-} + 6I^- + 14H^+ \rightarrow 2Cr^{3+} + 3I_2 + 7H_2O \quad \textbf{equation 4.7}$$

$$I_2 + 2Na_2S_2O_3 \rightarrow Na_2S_4O_6 + 2I^- \quad \textbf{equation 4.8}$$

Some students add acid and 20.0 cm^3 of 0.200 mol dm^{-3} $Cr_2O_7^{2-}$ to 25.0 cm^3 of a 'low-alcohol' beer.

They add excess iodide ions and find that the iodine produced reacts with 27.6 cm^3 of 0.100 mol dm^{-3} $Na_2S_2O_3$.

Calculate the concentration of the ethanol in the beer (in mol dm^{-3}) and then the percentage of ethanol (in g per 100 cm^3).

concentration of ethanol = _____ moldm^{-3}

% ethanol = _____ g/100 cm^3 **[6]**

(ii) Suggest one assumption the students have to make when giving their result. **[1]**

Total Marks for Question Set 4: 24

The Periodic Table of the Elements

(1)	(2)											(3)	(4)	(5)	(6)	(7)	(0)
1																	18
1 H hydrogen 1.0	2											13	14	15	16	17	2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0											5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
11 Na sodium 23.0	12 Mg magnesium 24.3	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium	85 At astatine	86 Rn radon
87 Fr francium	88 Ra radium	89–103 actinoids	104 Rf rutherfordium	105 Db dubnium	106 Sg seaborgium	107 Bh bohrium	108 Hs hassium	109 Mt meitnerium	110 Ds darmstadtium	111 Rg roentgenium	112 Cn copernicium		114 Fl flerovium		116 Lv livermorium		

57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.2	61 Pm promethium 144.9	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.2	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.0	71 Lu lutetium 175.0
89 Ac actinium	90 Th thorium 232.0	91 Pa protactinium	92 U uranium 238.1	93 Np neptunium	94 Pu plutonium	95 Am americium	96 Cm curium	97 Bk berkelium	98 Cf californium	99 Es einsteinium	100 Fm fermium	101 Md mendelevium	102 No nobelium	103 Lr lawrencium

Key
atomic number
Symbol
name
relative atomic mass