3

90696

Level 3 Chemistry, 2005

90696 Describe oxidation-reduction processes

Interactive paper

Credits: Three

You should answer ALL the questions in this paper.

Show all working for all calculations.

A periodic table is provided at the end of this paper.

Type your answers in the fields provided. Copy and paste any special characters needed from the box at the top of each page. Use the *Comment and Markup* tools to draw diagrams, circle options and so on. When you have finished, click the Show Answers button at the end of the paper. This will reveal the answers and marking schedule, and boxes for you to enter the grades (N, A, M or E). As you mark the paper your totals and overall performance will appear in the boxes below.

For Assessor's use only **Achievement Criteria**		
Achievement	**Achievement with Merit**	**Achievement with Excellence**
Identify and describe oxidation-reduction processes.	Use information about oxidation-reduction processes.	Analyse and interpret information about oxidation-reduction processes.
Overall Level of Performance		

You are advised to spend 30 minutes answering the questions in this booklet.

QUESTION ONE: COBALT AND CHROMIUM IN REDOX REACTIONS

An electrochemical cell is set up using appropriate electrodes and solutions of potassium dichromate and cobalt(II) nitrate. It is based on the following half-cell reactions:

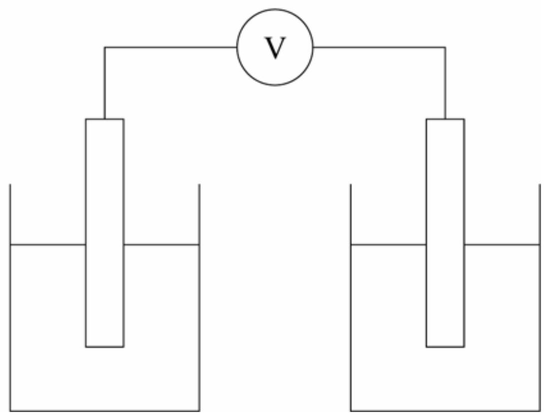
$Co^{2+} + 2e^- \rightarrow Co$ $\qquad E° = –0.28$ V

$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$ $\qquad E° = +1.36$ V

(a) Write a balanced equation for the spontaneous reaction that would occur in the cell.

(b) Calculate the *E*° for the spontaneous reaction in the above cell.

(c) **Complete** the diagram below to show how the electrochemical cell would be set up. On your diagram **label** the electrodes, the solutions (electrolytes) and indicate the **direction** of the flow of charge (cations, anions and electrons) between the two half-cells.



(d) Complete the standard cell diagram for this cell.

| || |

(e) Cobalt is a transition metal that exists in both the +2 and +3 oxidation states.

A piece of cobalt metal is reacted with acidified potassium dichromate solution.

Using the relevant reduction potentials, determine if the cobalt ion produced in this reaction is Co^{2+} or Co^{3+}.

$$E°(Co^{3+}/Co^{2+}) = +1.82\ V$$

(f) Use the information below to arrange the standard reduction potentials $E°(Co^{3+}/Co^{2+})$, $E°(U^{4+}/U^{3+})$, $E°(Fe^{3+}/Fe^{2+})$ from highest to lowest **and** identify the ion that is the strongest oxidant. Justify your answer.

$U^{3+}(aq) + Co^{3+}(aq) \rightarrow Co^{2+}(aq) + U^{4+}(aq)$ (1)

$Fe^{2+}(aq) + U^{4+}(aq) \rightarrow$ no reaction (2)

$Co^{3+}(aq) + Fe^{2+}(aq) \rightarrow Co^{2+}(aq) + Fe^{3+}(aq)$ (3)

QUESTION TWO: CAR BATTERIES

Lead storage batteries have been used in cars for the past 85 years. The spontaneous reaction for each cell in the battery is:

$$Pb(s) + PbO_2(s) + 2H_2SO_4(aq) \rightarrow 2PbSO_4(s) + 2H_2O(\ell)$$

(a) (i) Give the oxidation numbers for lead in:

Pb __________ PbO_2 __________ $PbSO_4$ __________

(ii) Show how these oxidation numbers can be used to identify the oxidant and reductant in the cell reaction.

(b) Write balanced half-equations for the reactions occurring at the anode and the cathode of each cell in the battery.

Anode:

Cathode:

QUESTION THREE: ANALYSIS OF COPPER IN BRASS

In an analysis of the amount of **copper** in a brass screw, the following series of reactions were carried out.

Step 1 The brass screw was placed in concentrated nitric acid and left until the reaction was complete.

Step 2 Aqueous potassium iodide was added. Reaction occurred to give a white precipitate in a yellow-brown solution.

Step 3 The mixture was filtered to remove the white precipitate. The remaining yellow-brown solution was titrated with sodium thiosulfate (using starch as an indicator). At the end point of the titration, the solution was colourless.

(a) Describe the observations that would be made as step 1 is carried out.

→ ⇌ × ÷ – √ ∛ ½ Δ Σ δ ° | —

(b) Write balanced half-equations for the reaction of copper with concentrated nitric acid.

(c) Account for the observations at steps 2 and 3 by identifying the reactions occurring. Include balanced equations for each reaction.

Step 2:

Step 3:

Mark Answers

PERIODIC TABLE OF THE ELEMENTS

Atomic Number: 1; H; 1.0 Molar Mass/ g mol^{-1}

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.0																	2 **He** 4.0
3 **Li** 6.9	4 **Be** 9.0											5 **B** 10.8	6 **C** 12.0	7 **N** 14.0	8 **O** 16.0	9 **F** 19.0	10 **Ne** 20.2
11 **Na** 23.0	12 **Mg** 24.3											13 **Al** 27.0	14 **Si** 28.1	15 **P** 31.0	16 **S** 32.1	17 **Cl** 35.5	18 **Ar** 40.0
19 **K** 39.1	20 **Ca** 40.1	21 **Sc** 45.0	22 **Ti** 47.9	23 **V** 50.9	24 **Cr** 52.0	25 **Mn** 54.9	26 **Fe** 55.9	27 **Co** 58.9	28 **Ni** 58.7	29 **Cu** 63.6	30 **Zn** 65.4	31 **Ga** 69.7	32 **Ge** 72.6	33 **As** 74.9	34 **Se** 79.0	35 **Br** 79.9	36 **Kr** 83.8
37 **Rb** 85.5	38 **Sr** 87.6	39 **Y** 88.9	40 **Zr** 91.2	41 **Nb** 92.9	42 **Mo** 95.9	43 **Tc** 98.9	44 **Ru** 101	45 **Rh** 103	46 **Pd** 106	47 **Ag** 108	48 **Cd** 112	49 **In** 115	50 **Sn** 119	51 **Sb** 122	52 **Te** 128	53 **I** 127	54 **Xe** 131
55 **Cs** 133	56 **Ba** 137	71 **Lu** 175	72 **Hf** 179	73 **Ta** 181	74 **W** 184	75 **Re** 186	76 **Os** 190	77 **Ir** 192	78 **Pt** 195	79 **Au** 197	80 **Hg** 201	81 **Tl** 204	82 **Pb** 207	83 **Bi** 209	84 **Po** 210	85 **At** 210	86 **Rn** 222
87 **Fr** 223	88 **Ra** 226	103 **Lr** 262	104 **Rf** 261	105 **Db** 262	106 **Sg** 263	107 **Bh** 264	108 **Hs** 265	109 **Mt** 268									

Lanthanide Series	57 **La** 139	58 **Ce** 140	59 **Pr** 141	60 **Nd** 144	61 **Pm** 147	62 **Sm** 150	63 **Eu** 152	64 **Gd** 157	65 **Tb** 159	66 **Dy** 163	67 **Ho** 165	68 **Er** 167	69 **Tm** 169	70 **Yb** 173
Actinide Series	89 **Ac** 227	90 **Th** 232	91 **Pa** 231	92 **U** 238	93 **Np** 237	94 **Pu** 239	95 **Am** 241	96 **Cm** 244	97 **Bk** 249	98 **Cf** 251	99 **Es** 252	100 **Fm** 257	101 **Md** 258	102 **No** 259