Chemistry Department
Christ Church Grammar School

Year 12
2022

Redox Topic Test

Time allowed: 45 minutes

Instructions
Please ensure you enter your name and circle your teacher's initials below.
Scientific calculators only.
Chemistry Data Sheet will be provided

Name

_____

Teacher: (circle)

BLR NMO MXC

Mark:_____ **/ 51**

Section 1: Multiple Choice (Total 10 marks)

Circle the correct option

1. Which of the following is **not** an oxidation-reduction reaction?

A. $2H_2O \rightarrow 2H_2 + O_2$

B. $Cu + Ag^+ \rightarrow Cu^{2+} + Ag$

C. $A\ell(OH)_3 \rightarrow 3H_2O + A\ell_2O_3$

D. $Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$

2. Iodide ion (I^-) can be oxidized spontaneously by X but not by Y. The identities of X and Y, respectively, could be

	X		Y
A.	bromine	and	chlorine
B.	gold (III) ions	and	silver ions
C.	acidified MnO_4^-	and	acidified hydrogen peroxide
D.	iron (III) ions	and	nickel ions

3. A solution of sulfur dioxide in water is a strong bleach, decolourising substances by the reducing agent SO_2 in solution. Which one of the following lists of species will **all** be reduced by the sulfur dioxide solution, given the standard reduction potential for the reduction reaction?

$$SO_4^{2-} + 4H^+ + 2e^- \rightleftharpoons SO_2 + 2H_2O \qquad E^0 = +0.17\ V$$

A. Br^-, Cl^-, I^-

B. $Cu^{2+}, Sn^{2+}, Co^{2+}$

C. Mn^{2+}, Fe^{3+}, K^+

D. Br_2, Cl_2, I_2

4. In which one of the following reactions is the chlorine increasing in oxidation number by 1?

A. $PC\ell_3 + C\ell_2 \rightarrow PC\ell_5$

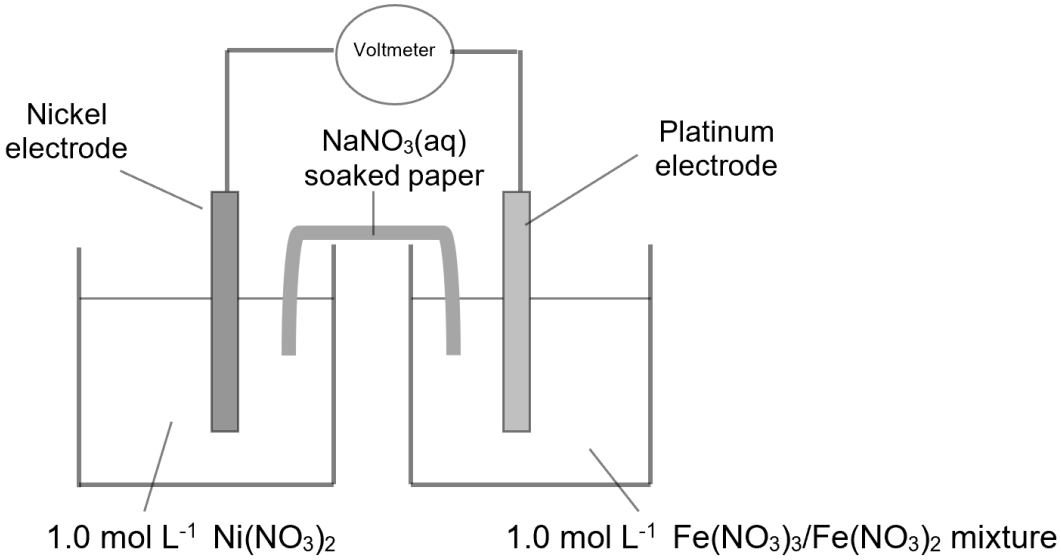
B. $C\ell_2 + H_2O \rightarrow C\ell^- + HC\ell O + H^+$

C. $F_2 + 2\ C\ell^- \rightarrow C\ell_2 + 2\ F^-$

D. $HC\ell O + H_2O_2 \rightarrow HC\ell O_3 + H_2O$

The following diagram relates to questions 5 and 6.

Consider the following galvanic cell.



5. Which one of the following correctly describes the observations in the right-hand half-cell?

A. The solution becomes more brown.

B. The solution becomes more green.

C. A grey solid is deposited on the platinum electrode.

D. The platinum electrode dissolves into the solution.

6. Which one of the following correctly describes the movement of electrons in the external circuit and the sodium ions in the salt bridge?

	electrons	**sodium ions**
A.	to the right	to the right
B.	to the right	to the left
C.	to the left	to the right
D.	to the left	to the left

7. Which one if the following is **not** a similarity between an electrolytic cell and a galvanic cell?

A. They both require a spontaneous redox reaction.

B. Reduction occurs at the cathode.

C. Electrons move away from anode through an external circuit.

D. Positive ions migrate towards the cathode.

8. The following reaction represents the oxidation of thiosulfate ($S_2O_3^{2-}$) to tetrathionate ($S_4O_6^{2-}$) by iodine.

$$I_2(aq) + 2\ S_2O_3^{2-}(aq) \rightarrow 2\ I^-(aq) + S_4O_6^{2-}(aq)$$

This redox reaction was used as the basis for a galvanic cell and the EMF was measured to be +0.46 V under standard conditions.

What is the value of the standard reduction potential (E^0) for the conversion of tetrathionate ($S_4O_6^{2-}$) to thiosulfate ($S_2O_3^{2-}$)?

A. - 0.08 V

B. + 0.08 V

C. - 1.00 V

D. + 1.00 V

9. During the process of electrorefining impure (blister) copper, several different metal impurities are removed. Which statement is **incorrect** regarding the various metal impurities found in blister copper?

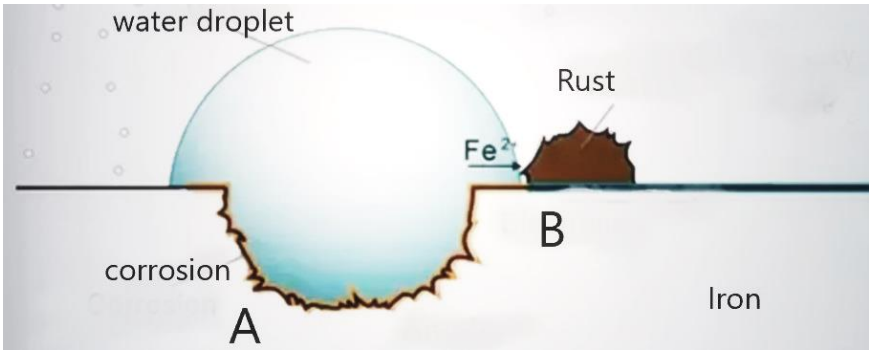
A. Ag would be found in the anode slime

B. Zn would be oxidised to $Zn^{2+}(aq)$

C. Ni would be found in the anode sludge

D. Fe would be oxidised to $Fe^{2+}(aq)$

10. The corrosion of iron occurs in two stages. During the first stage, an electrochemical cell is established on the iron surface. This can be seen in the following diagram.



Which of the following correctly identifies the anode, cathode and direction of electron flow?

	anode	cathode	direction of electron flow
A.	B	A	A → B
B.	A	B	B → A
C.	B	A	B → A
D.	A	B	A → B

END OF SECTION 1

Section 2: Short Answer (Total 37 marks)

Question 11 3 marks

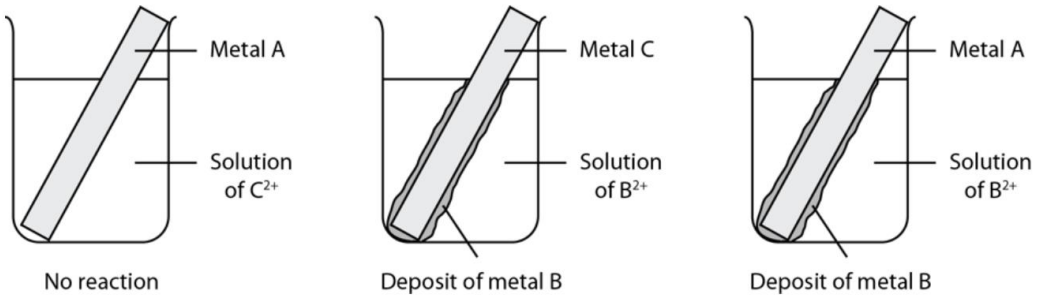
Assign oxidation numbers to the element in bold type in each of following:

(a) $Na_3\mathbf{P}O_4$ (b) $H_2\mathbf{C}_2O_4$ (c) $\mathbf{Fe}(CN)_6^{3-}$

+5 +3 +3

Question 12 5 marks

An experiment was conducted to investigate redox reactions involving metals. Metal strips were placed in a solution containing cations of a different metal. The results from these experiments are shown in the diagrams below.



(a) List the metals in order of increasing strength as a reductant. (2 marks)

B, A, C (-1) each error (0) if cations used

(b) If the solution of B^{2+} is pale green and C^{2+} is pale pink. Use your data sheet to identify the species involved.

(3 marks)

metal	**A**	**B**	**C**
symbol	Zn	Fe	Mn
cation	**A^{2+}**	**B^{2+}**	**C^{2+}**
symbol	Zn^{2+}	Fe^{2+}	Mn^{2+}

Question 13 **12 marks**

(a) Chlorine water is mixed with a solution of potassium iodide.

(i) Write balanced half-equations and the overall redox equation.

(3 marks)

Oxidation half equation	$2I^- \rightarrow I_2 + 2e^-$ (1)
Reduction half equation	$Cl_2 + 2e^- \rightarrow 2Cl^-$ (1)
Overall redox equation	$2I^- + Cl_2 \rightarrow I_2 + 2Cl^-$ (1)

(ii) Write observations for the above reaction (2 marks)

A pale yellow solution is added to a colourless solution and the solution turns brown.

(iii) A small amount of the organic solvent dichloromethane is then added. What additional observations would be made, if any? (1 mark)

Two layers are formed the top layer is less brown and the bottom layer is purple. (Must state change brown – purple)

(b) Complete and balance the redox reaction below in acidic conditions by first writing the half-equations for oxidation and reduction and then writing the overall redox reaction.

$As_2O_3(s) + NO_3^-(aq) \rightarrow H_3AsO_4(aq) + NO(g)$

(6 marks)

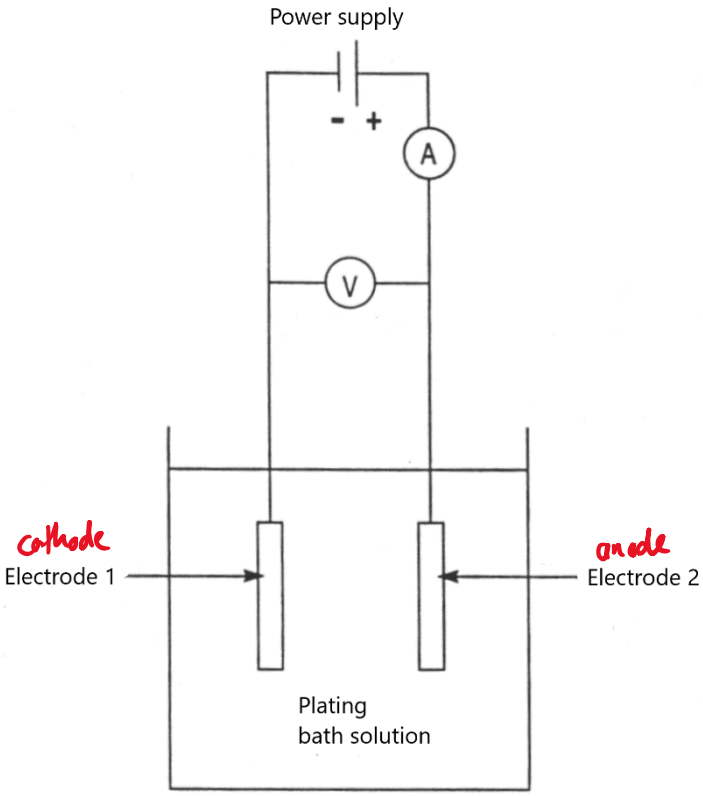
Oxidation half equation	$As_2O_3 + 5H_2O \rightarrow 2H_3AsO_4 + 4e^- + 4H^+$ ×3
Reduction half equation	$NO_3^- + 3e^- + 4H^+ \rightarrow NO + 2H_2O$ ×4
Overall redox equation	$3As_2O_3 + 7H_2O + 4NO_3^- + 4H^+ \rightarrow 6H_3AsO_4 + 4NO$

Question 14 **5 marks**

Electroplating products with silver can provide multiple benefits to a product including protection from corrosion, resistance to wear and higher electrical conductivity.

The diagram on the right shows an electrolytic cell that could be used to silver plate an object.

As the cell operates silver from the plating bath solution is used to coat an object on one of the electrodes.



(a) At which electrode would you place the object to be silver plated?

(1 mark)

Electrode 1.

(b) Name a suitable electrolyte that could be used as the plating bath solution.

(1 mark)

Silver nitrate solution

(c) Explain why the voltage used on the power supply is only 1-2 V. (1 mark)

Low voltage required to overcome the internal resistance of the circuit.

(d) Write half-equations for the reactions occurring at the anode and cathode.

(2 marks)

Anode	$Ag \rightarrow Ag^+ + e^-$
Cathode	$Ag^+ + e^- \rightarrow Ag$

Question 15 **12 marks**

The standard reduction potentials listed on the data sheet are measured by recording the potential of the galvanic cell created when the relevant half-cell is combined with the hydrogen half-cell. The hydrogen half-cell comprises of a solution of 1.00 mol L^{-1} $H^+(aq)$ ions, in contact with hydrogen gas at a pressure of 100 KPa on the surface of a platinum electrode.

(a) In the space below, draw labelled diagram of the galvanic cell required to measure the standard electrode potential for the following reaction:

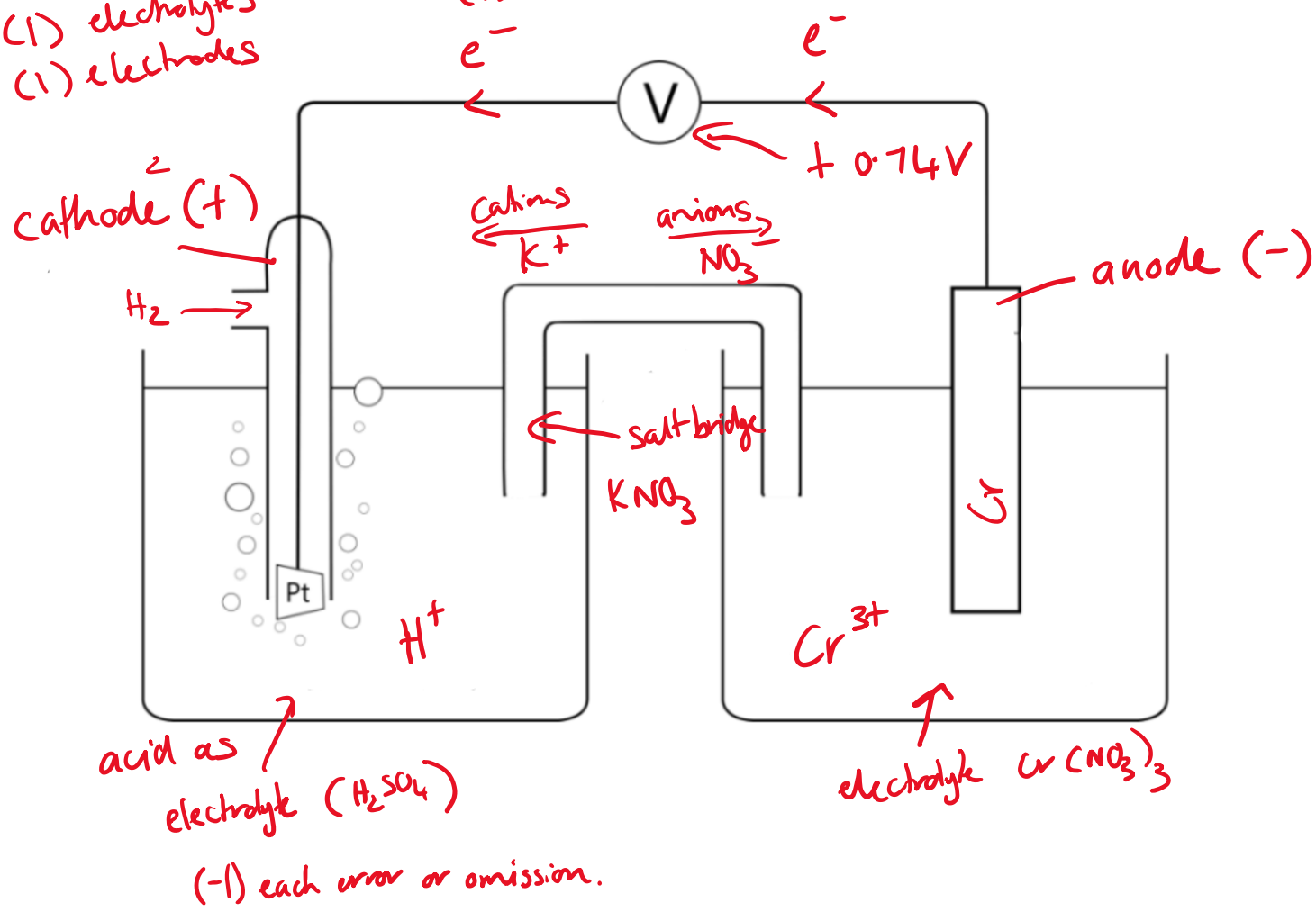
$Cr^{3+}(aq) + 3\,e^- \rightleftharpoons Cr(s)$

Fully label your diagram including the anode, cathode, polarity of the electrodes, direction of electron flow, direction of ion flow in the salt bridge, the value of the reading on the voltmeter and all required chemical species including electrodes, electrolytes and salt bridge.

(7 marks)

(1) anode / cathode
(1) electrode polarity
(1) electrolytes
(1) electrodes

(1) electron flow
(1) salt bridge / ion flow
(1) voltmeter



(-1) each error or omission.

(b) Why is the standard hydrogen electrode used by scientists as a reference on all half-cell potential reactions? (1 mark)

The E° value for the reduction reaction is 0V.

∴ voltage output of cell indicates the E° value of the oxidation half cell.

Question 15 (continued)

(c) Determine the overall redox equation for the reaction occurring in the cell.

(2 marks)

Anode	$Cr \rightarrow Cr^{3+} + 3e^-$	$\times 2$
Cathode	$2H^+ + 2e^- \rightarrow H_2$	$\times 3$
Overall Reaction	$2Cr + 6H^+ \rightarrow 2Cr^{3+} + 3H_2$	(2)

(-1 each error or omission)

(d) 0.15 moles of electrons passes through the external circuit of the cell described on page 9. Determine the change in mass of the anode (if any).

(2 marks)

$n(Cr)_{\text{lost from anode}} = \frac{n(e^-)}{3}$

$= \frac{0.15}{3}$

$= 0.05$ mol (1)

$m(Cr)_{\text{lost}} = n \times M$

$= 0.05 \times 52.00$

$= 2.6$ g (1)

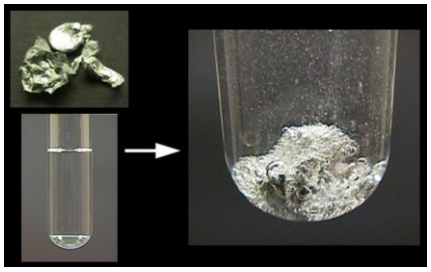
See next page

Question 16 **4 marks**

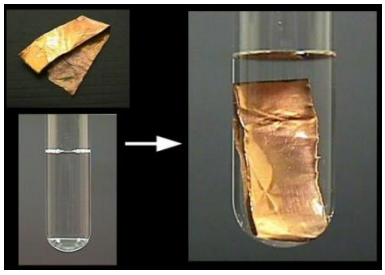
A student was investigating the reactions of acids and metals.

In Test tube A they placed a small lump of zinc and 1.0 mol L^{-1} HCℓ and Test tube B they placed a small strip of copper and 1.0 mol L^{-1} HCℓ. They took photos of their results below.

Test tube A



Test tube B



The student then wrapped a lump of zinc with copper so that half the zinc was exposed and half was covered with copper and placed this into Test tube C so that it was fully covered in 1.0 mol L^{-1} HCℓ.

Fully describe the observations you would make in Test tube C and explain any differences between observations in Test tube C and the initial tests in Test tubes A and B.

Bubbles of a colourless gas are produced that form on the salmon pink solid. (1)
(not the silver/grey solid)
The silver/grey solid dissolves and the salmon pink solid remains in a colourless solution. (1)
The zinc reacts more vigorously/rapidly as the copper touching the zinc transfers electrons from zinc more easily enabling the zinc to be more readily oxidised. (1) (1)

END OF TEST

Spare working paper if required