Chemistry Department
Christ Church Grammar School

Year 12
2020

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 Solutions

Teacher: (circle)

CEM NMO KLD MXC

Mark:_____ / ~~44~~ 45.

Section 1: Multiple Choice **(Total 10 marks)**

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

   A. $4\ CuO + CH_4 \rightarrow 4\ Cu + 2\ H_2O + CO_2$

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

   C. $Zn + 4\ HNO_3 \rightarrow Zn(NO_3)_2 + 2\ NO_2 + 2\ H_2O$

   D. $CaCO_3 \rightarrow CaO + CO_2$

2. Which of the following compounds of manganese could be **reduced** to form the other three?

   A. MnO

   B. MnO_2

   C. $KMnO_4$

   D. K_2MnO_4

3. Which of the following contains sulfur in the lowest oxidation state (oxidation number)?

   A. $S_2O_6^{2-}$

   B. $S_2O_4^{2-}$

   C. $S_2O_8^{2-}$

   D. $S_4O_6^{2-}$

4. In an experiment, an excess of gaseous bromine is bubbled through a solution that is a mixture of potassium iodide and sodium chloride. It would be expected that the bromine would react with

   A. the chloride ions only.

   B. the iodide ions only.

   C. both the chloride ions and the iodide ions.

   D. neither the chloride ions nor the iodide ions.

5. Which of the following reaction types are redox reactions?

I. The reaction of a metal with an acid
II. A metal displacement reaction
III. The reaction between an acid and a metal hydroxide
IV. A halogen displacement reaction

A. II and IV only
B. I, II and IV only
C. I, II and III only
D. II and III only

6. Despite having been developed over 150 years ago, lead-acid accumulator batteries are still used in many vehicles. The overall equation for the reaction taking place when a lead-acid battery discharges is:

$$Pb + PbO_2 + 2SO_4^{2-} + 4H^+ \rightarrow 2PbSO_4 + 2H_2O$$

Which of the following represents the half-cell reaction at the **negative** electrode of the battery?

A. $Pb + SO_4^{2-} \rightarrow PbSO_4 + 2e^-$
B. $PbSO_4 + 2e^- \rightarrow Pb + SO_4^{2-}$
C. $PbO_2 + SO_4^{2-} + 4H^+ + 2e^- \rightarrow PbSO_4 + 2H_2O$
D. $PbSO_4 + 2H_2O \rightarrow PbO_2 + SO_4^{2-} + 4H^+ + 2e^-$

7. In a redox reaction, the oxidation number of aluminium changed from +3 to 0. From this it may be concluded that aluminium:

A. lost 3 electrons and was the reducing agent
B. lost 3 electrons and was the oxidising agent
C. gained 3 electrons and was the oxidising agent
D. gained 3 electrons and was the reducing agent

8. Under standard conditions, Ni(s) will react spontaneously with

A. $C\ell^-$
B. Ag^+
C. Cr^{3+}
D. Co^{2+}

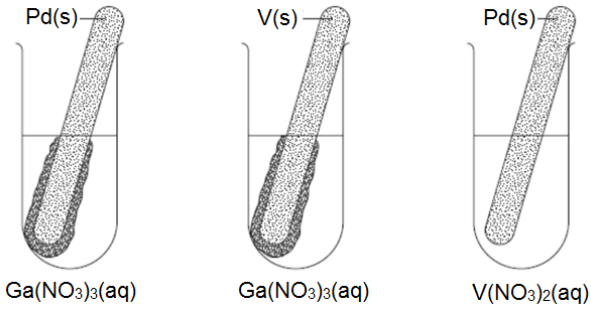
9. An electrochemical cell based on the following reaction has an $E^{o} = 1.03$ V.

$$C\ell_2(g) + 2\ V^{3+}(aq) + 2\ H_2O(\ell) \rightarrow 2\ VO^{2+}(aq) + 4\ H^{+}(aq) + 2\ C\ell^{-}(aq)$$

What is the standard reduction potential for the reduction of $VO^{2+}(aq)$ to $V^{3+}(aq)$?

A. –3.05 V
B. –0.33 V
C. +0.33 V
D. +3.05 V

10. A student performed three tests to investigate the relative activity of three metals; gallium (Ga), palladium (Pd) and vanadium (V). A strip of each one of the metals was placed in a solution containing the nitrate salt of one of the other different metals. The results are shown in the diagrams below.



Based on these observations, which of the following lists the metals from highest to lowest in terms of their strength as reductants?

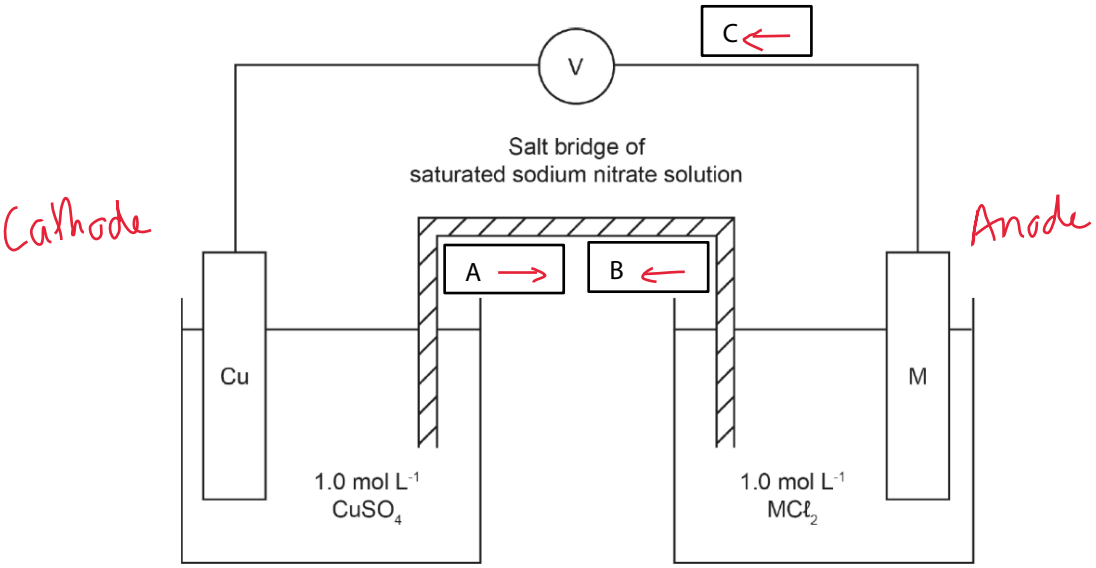
A. Pd > Ga > V
B. V > Ga > Pd
C. V > Pd > Ga
D. Pd > V > Ga

END OF SECTION 1

Section 2: Short Answer **(Total 34 marks)**

Question 11 **(9 marks)**

The diagram below represents a galvanic cell at 25 °C. One electrode/electrolyte pair is Cu/Cu^{2+}. The other electrode is of an unknown metal, represented as M/M^{2+}.



It was observed, that over time, the unknown metal electrode reduced in size and the solution containing MCl_2 remained colourless.

(a) Write the equations for the anode and cathode half-cells. (2 marks)

Anode $M \rightarrow M^{2+} + 2e^-$ (1)

Cathode $Cu^{2+} + 2e^- \rightarrow Cu$ (1)

(b) Draw an arrow inside each of box A, B and C on the diagram above to clearly indicate (2 marks)

(i) the direction of movement of anions in the salt bridge in box A
(ii) the direction of movement of cations in the salt bridge in box B } (1)
(iii) the direction of electron flow through the external circuit in box C (1)

(c) List two observations you would expect to see in the Cu/Cu^{2+} half cell. (2 marks)

Observation 1 The electrode would increase in size as a salmon pink solid is deposited (1)

Observation 2 The solution will become paler blue in colour (1)

(d) The predicted EMF of the galvanic cell is 1.10 V. Determine the identity of the unknown metal M. Show your reasoning. (3 marks)

$Cu^{2+} + 2e^- \rightarrow Cu$ 0.34 V (1)

$1.10 - 0.34 = 0.76$ V (1)

$Zn \rightarrow Zn^{2+} + 2e^-$ 0.76 V

∴ metal M is Zn (1)

Question 12 9 ~~/8~~ **marks)**

Write balanced half-equations and a full equation that account for the following observations.

(a) A silver/grey solid is added to a pink solution, a silver/grey solid deposits on the surface of the solid and the solution turns pale green.

Oxidation half equation	$Fe \rightarrow Fe^{2+} + 2e^-$ (1)
Reduction half equation	$Co^{2+} + 2e^- \rightarrow Co$ (1)
Full redox equation	$Fe + Co^{2+} \rightarrow Fe^{2+} + Co$ (1)

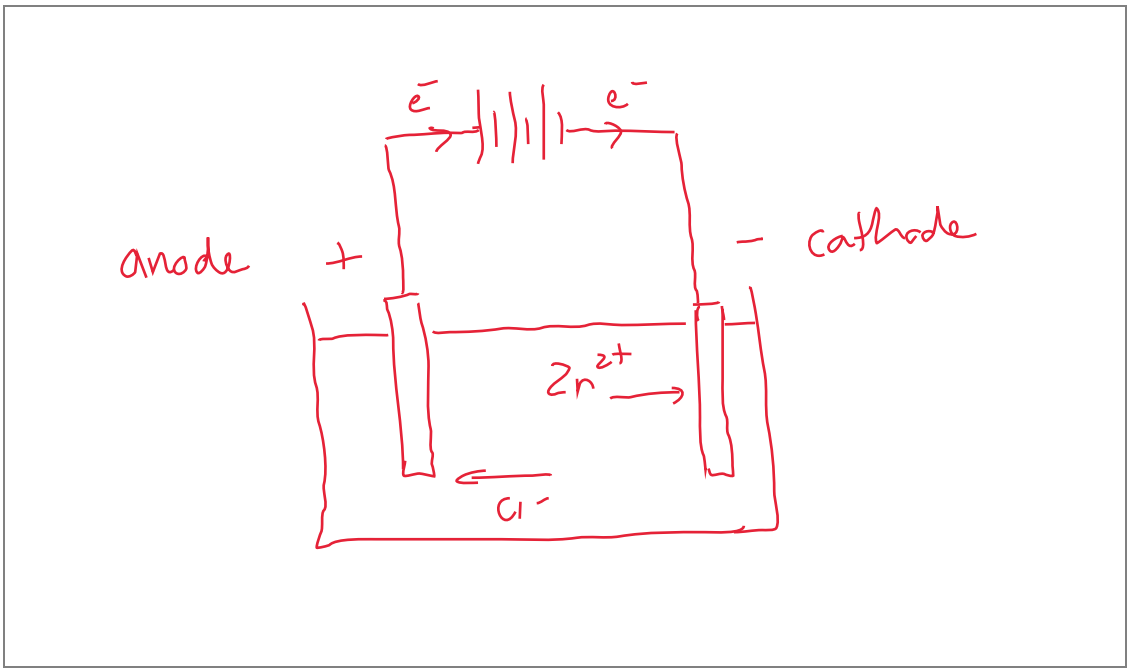
(b) Solid sulfur is added to an acidified potassium iodate (KIO_3) solution and the mixture is heated, a colourless gas with a pungent odour (SO_2) evolves and the solution becomes brown in colour.

Oxidation half equation (2)	$S + 2H_2O \rightarrow SO_2 + 4H^+ + 4e^-$ $\times 5$
Reduction half equation (2)	$2IO_3^- + 12H^+ + 10e^- \rightarrow I_2 + 6H_2O$ $\times 2$
Full redox equation (2)	$5S + 4IO_3^- + 4H^+ \rightarrow 5SO_2 + 2I_2 + 2H_2O$

Question 13 **(6 marks)**

Consider an electrolytic cell constructed using an external power source, graphite electrodes and a beaker of molten salt, zinc chloride.

(a) In the space below, sketch a diagram for this electrolytic cell.
Clearly label your diagram with:
- the anode and cathode (1)
- the direction of flow of electrons in the external circuit (1)
- the direction of flow of anions and cations in the solution (1) (3 marks)



As the cell operates, a grey solid deposits on the surface of one of the electrodes and bubbles of a greenish yellow gas form on the surface of the other electrode.

(b) Write half-equations for the reactions occurring at the anode and cathode and the overall reaction.

(3 marks)

Anode (1)	$2Cl^- \rightarrow Cl_2 + 2e^-$
Cathode (1)	$Zn^{2+} + 2e^- \rightarrow Zn$
Overall Reaction (1)	$Zn^{2+} + 2Cl^- \rightarrow Cl_2 + Zn$

Question 14 **(8 marks)**

In an attempt to discover more about the chemistry of the chemistry of niobioum (Nb, atomic number 41), a chemist performed the following procedure

- He took two strips of niobium metal.
- He added one strip to 1.0molL^{-1} hydrochloric acid and he observed that bubbles of hydrogen gas were given off.
- He correctly concluded that the niobium had been oxidized but he had no way of knowing what was the charge on the aqueous niobium ions (Nb^{x+}) formed.
- He then took the other strip of niobium and placed it into his solution of niobium ions
- He connected this Nb^{x+}/Nb half cell to a Ni^{2+}/Ni half cell and took the following measurements of the masses of the two electrodes

	Initial mass (g)	Final mass (g)
niobium	3.67	3.40
nickel	5.08	5.34

→ mass decrease anode

→ mass increase cathode

- The voltage of the cell was found to be 0.86 V

(a) Determine the standard reduction potential of the Nb^{x+}/Nb half cell. Show clearly how you arrived at this value. (3 marks)

Cathode $Ni^{2+} + 2e^- \rightarrow Ni$ E° -0.24 V (1)

Anode $Nb \rightarrow Nb^{x+} + xe^-$ $+1.10$ V (1)

0.86 V

∴ Standard red potential of Nb^{x+}/Nb half cell is -1.10 V (1)

Max (2) if not clear.

(b) Calculate the value of x in the aqueous niobium (Nb^{x+}) ions. (5 marks)

$m(Ni) = 5.34 - 5.08$

$= 0.26$ g

$n(Ni) = \frac{0.26}{58.69} = 0.00443$ moles (1)

$n(e^-) = 0.00443 \times 2$

$= 0.00886$ moles (1)

$m(Nb) = 3.67 - 3.40$

$= 0.27$ g

$n(Nb) = \frac{0.27}{92.91}$ (1)

$= 0.002906$ moles

Valence $X = \frac{n(e^-)}{n(Nb)}$

$= \frac{0.00886}{0.002906}$ (1)

$= 3.05$

∴ $X = 3$ (1)

Question 15 **(3 marks)**

Consider the following set of reactions between A^{3+}, B^{3+}, C^{3+} with A^{+}, B^{2+}, C^{2+}

$2\ B^{2+} + A^{3+} \rightarrow 2\ B^{3+} + A^{+}$

$A^{+} + 2\ C^{3+} \rightarrow 2\ C^{2+} + A^{3+}$

Using the above results:

(a) List the oxidizing agents from strongest to weakest. → highest reduction potential

C^{3+}, A^{3+}, B^{3+} (2)

(b) Write an ionic equation between C^{2+} ions and B^{3+}

either $B^{3+} + C^{2+} \rightarrow C^{3+} + B^{2+}$

or No reaction (1)

C^{3+} before A^{3+} (1)

A^{3+} before B^{3+} (1)

If C, A, B (1) only

END OF TEST

$A^{3+} + 2e^{-} \rightarrow A^{+}$

$B^{3+} + e^{-} \rightarrow B^{2+}$

$C^{3+} + e^{-} \rightarrow C^{2+}$

Note: $C^{3+} + B^{2+} \rightarrow B^{3+} + C^{2+}$

no marks as doesn't follow Qu instructions