TRIAL TEST 3: OXIDATION AND REDUCTION

Time allowed:	70 minutes	Section 1 – Multiple Choice	20 marks
Total marks:	80	Section 2 – Short & Extended Answer	60 marks

SECTION 1 – MULTIPLE CHOICE (20 MARKS)

1. A test for nitrates is given by the equation below.

$$4Zn_{(s)} + NO_3^-{}_{(aq)} + 7OH^-{}_{(aq)} + 6H_2O_{(l)} \rightarrow 4[Zn(OH)_4]^{2-}{}_{(aq)} + NH_{3(g)}$$

The element that has been reduced in this process has experienced a change in oxidation number of:

(a) 2
(b) 4
(c) 6
(d) 8

2. I. $Zn^{2+}{}_{(aq)} + 4NH_{3(aq)} \rightarrow [Zn(NH_3)_4]^{2+}{}_{(aq)}$

II. $4H^+{}_{(aq)} + 2VO_2^+{}_{(aq)} + Sn^{2+}{}_{(aq)} \rightarrow Sn^{4+}{}_{(aq)} + 2VO^{2+}{}_{(aq)} + 2H_2O_{(l)}$

III. $Zn^{2+}{}_{(aq)} + 2Cl^-{}_{(aq)} \rightarrow Zn_{(s)} + Cl_{2(g)}$

IV. $BaCO_{3(s)} + 2H^+{}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow BaSO_{4(s)} + CO_{2(g)} + H_2O_{(l)}$

Which of the equations above show the **reduction** of a metal ion?

(a) I and II only.
(b) I and IV only.
(c) II and III only.
(d) II and IV only.

3. The equation for the addition of liquid bromine to a hot, concentrated solution of sodium hydroxide is:

$$3Br_{2(l)} + 6OH^-{}_{(aq)} \rightarrow 5Br^-{}_{(aq)} + BrO_3^-{}_{(aq)} + 3H_2O_{(l)}$$

For this process, which of the following statements is correct?

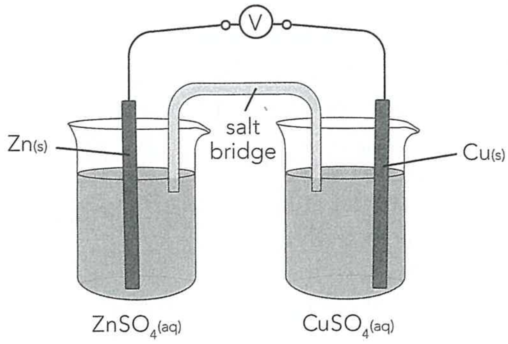
I. the hydrogen is reduced.
II. the bromine is oxidised.
III. the oxygen is the reducing agent.
IV. the bromine is the oxidising agent.

(a) I and II only.
(b) II and III only.
(c) I, II and IV only.
(d) II and IV only.

4. The E°_{TOTAL} or emf value for the "reaction" between 1 mol L^{-1} H_2O_2 and 1 mol L^{-1} $H_2C_2O_4$ solutions is +2.27 V. Upon mixing 1 mol L^{-1} solutions of these two chemicals a student failed to observe any signs of a chemical reaction. A possible reason for this is:

(a) the E°_{TOTAL} value for the reaction is not a predictor of reaction rate.
(b) the $H_2C_2O_4$ solution needs to be acidified.
(c) the reaction will only occur if a potential of greater than 2.27 V is applied to the reacting solutions.
(d) the reaction is endothermic and so needs energy to be added.

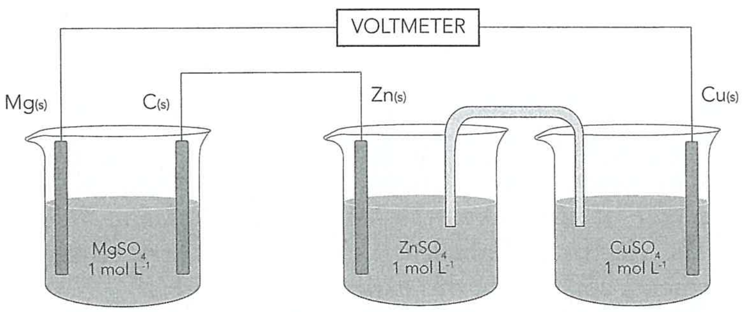
5.



Consider the galvanic cell shown above which is made up of Zn/Zn^{2+} and Cu/Cu^{2+} half cells. It would be correct to say that the reading on the voltmeter:

(a) is 1.10V
(b) is dependent on the surface area of the electrodes and the volume of the electrolyes
(c) is dependent on the temperature and concentration of the electrolyte solutions
(d) will become zero when Cu^{2+} ions stop moving through the salt bridge.

6. The diagram below shows two galvanic cells connected in series. The total emf for cells connected in series is the arithmetic addition of the each individual cell's emf.



The standard reduction potentials are given below:

$Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$ E° = −2.36 V

$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$ E° = −0.76 V

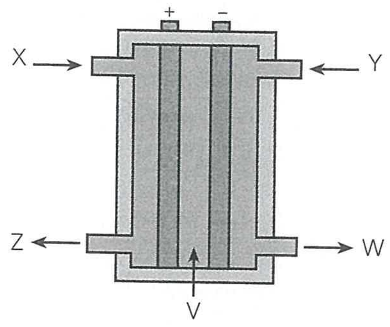
$2H^+(aq) + 2e^- \rightarrow H_2(g)$ E° = 0.00 V

$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ E° = +0.34 V

The reading on the voltmeter:

(a) cannot be calculated as the reduction potential for graphite ($C_{(s)}$) has not been provided.
(b) would be +3.12 V
(c) would be +1.26 V
(d) would be +3.46 V

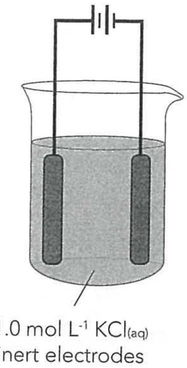
7. The diagram below shows a basic structure for a hydrogen/oxygen fuel cell.



Which of the following statements is correct?

(a) Label V refers to a solution of electrolyte.
(b) Label W refers to the oxygen gas outlet.
(c) Label X refers to the water inlet.
(d) Label Y refers to the electrolyte inlet.

8. A 1.0 mol L^{-1} solution of $KCl_{(aq)}$ is to be electrolysed using inert electrodes as shown. Which of the following is correct?



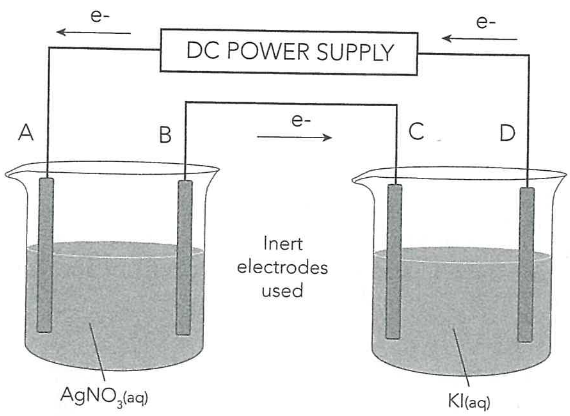
(a) Hydrogen gas is produced at the cathode.
(b) Potassium metal is produced at the anode.
(c) Oxygen gas is produced at the cathode.
(d) Potassium metal is produced at the cathode.

9. An industrial chemist was experimenting with the electrolysis of a sample of sea water using inert platinum electrodes. Which one of the following statements concerning the experiment is incorrect?

(a) The chemist needs to be careful not to produce sparks as hydrogen gas is produced at the cathode.
(b) The chemist could use this process to collect sodium metal that would deposit onto the cathode.
(c) With some further experimenting, the chemist could develop this process to produce sodium hydroxide.
(d) The chemist could increase the rate of the electrolytic process by adding NaCl(s) to the sea water.

10. An experiment was conducted using two electrolytic cells connected in series as shown. An external voltage of approximately 2.0V was applied and the aqueous solutions are both 1.0 M. The electrodes, labelled A, B, C and D, are all inert. Which one of the following statements concerning this experiment is correct?

(a) Anodic reactions will occur at both electrodes B and D.
(b) Oxygen gas is produced at electrode B.
(c) Potassium metal will form on electrode C.
(d) Silver metal will form on electrode B.



11. Write balanced, ionic equations for any reaction that occurs in the following experiments. In each case state all observations that would result from the chemical reaction.

(a) A bromine water solution is added to a sodium iodide solution.

EQUATION ______________________________

OBSERVATION ______________________________

____

(b) A zinc strip is placed into a solution of copper(II) sulfate.

EQUATION ______________________________

OBSERVATION ______________________________

____

(c) A piece of sodium is placed into a beaker of water.

EQUATION ______________________________

OBSERVATION ______________________________

____

(d) An acidified $KMnO_4$ solution is added dropwise to a H_2O_2 solution.

EQUATION ______________________________

OBSERVATION ______________________________

____

[12 marks]

12. (a) Rewrite the two redox equations shown below as oxidation and reduction half equations.

(i) $Zn_{(s)} + 2H^{+}_{(aq)} \rightarrow Zn^{+2}_{(aq)} + H_{2(g)}$

Oxidation half equation ______________________________

Reduction half equation ______________________________

(ii) $Mg_{(s)} + 2H_2O_{(l)} \rightarrow Mg(OH)_{2(aq)} + H_{2(g)}$

Oxidation half equation ______________________________

Reduction half equation ______________________________

(b) Write the oxidation and reduction half equations for the reactions indicated below. Also give the overall redox equation.

(i) A strip of zinc metal placed in a solution of silver nitrate begins to dissolve and a silvery deposit forms.

Oxidation half equation ______________________________

Reduction half equation ______________________________

Redox equation ______________________________

(ii) Magnesium metal reacts with chlorine gas to produce magnesium chloride.

Oxidation half equation ______________________________

Reduction half equation ______________________________

Redox equation ______________________________

[10 marks]

13. Complete the diagram below to illustrate a galvanic cell that uses magnesium and tin for the electrodes. Your diagram needs to clearly indicate each of the following:

(i) Direction of electron flow

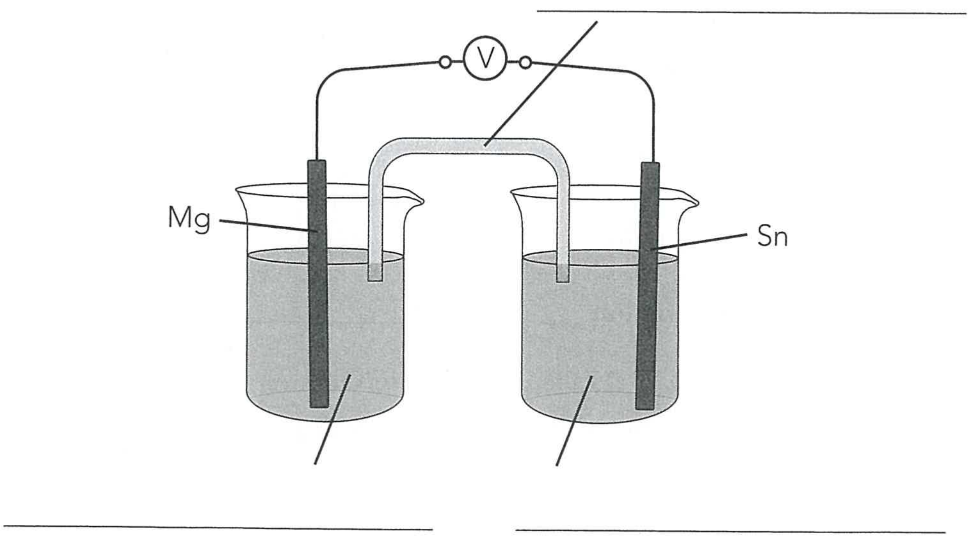
(ii) Direction of motion of +ve ions in the Mg half cell

(iii) Direction of motion of −ve ions in the salt bridge

(iv) Name of suitable solutions to use in the salt bridge and each half cell

(v) The reading on the voltmeter (assume standard conditions)

(vi) The equations for the reactions occurring at the anode and cathode



[12 marks]

14. A hobby farmer decided to restore a windmill that was used to pump ground water into a trough for stock to drink. After examining the steel support tower, the farmer found some evidence of rust.

(a) Write the anode and cathode half equations for the corrosion of the iron and the formation of rust.

Anode: ______________________________

Cathode: ______________________________

Rust formation: ______________________________

(b) Describe two procedures that the farmer could follow to prevent further corrosion of the iron tower. Explain in each case how the action taken prevents further corrosion.

(i) ______________________________

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____

(ii) ______________________________

____

____

[12 marks]

15. The corrosion of iron to form rust is caused by the action of oxygen and water in the air. The process occurs as a series of reactions.

(a) Give relevant equations for each of the following:

(i) The initial oxidation of the iron to form $Fe(OH)_{2(s)}$. Give the anodic, cathodic and overall reaction.

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(ii) The further oxidation of the $Fe(OH)_{2(s)}$ to $Fe(OH)_{3(s)}$.

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____

(iii) The partial dehydration to one of the forms of rust, $FeO_3.H_2O_{(s)}$.

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(b) Briefly outline two means of reducing the corrosion of iron. In each case explain why the method is effective.

(i)

(ii)

[14 marks]

END OF TEST (80 MARKS)

$n(Na_2CO_3)$ in 500 mL $= \frac{m}{M} = \frac{2.23}{105.99}$
$= 0.0210$ mol

$c(Na_2CO_3) = \frac{n}{V} = 0.0421 \text{ mol L}^{-1}$

$n(Na_2CO_3)$ used in titration $= cV$

$= 0.0421 \times 0.0200 = 8.42 \times 10^{-4}$ mol

$n(HCl) = 2n(Na_2CO_3)$

$= 2 \times 8.42 \times 10^{-4} = 1.68 \times 10^{-3}$

$c(HCl) = \frac{n}{V} = \frac{1.68 \times 10^{-3}}{0.0413}$

$= 4.08 \times 10^{-2} \text{ mol L}^{-1}$

TRIAL TEST 3: Oxidation and Reduction

Section 1

1. d	6. d
2. c	7. a
3. d	8. a
4. a	9. b
5. c	10. a

[20]

Section 2

11.
(a) Equation: $Br_{2(aq)} + 2I^-_{(aq)} \rightarrow 2Br^-_{(aq)} + I_{2(aq)}$
Observation: straw yellow solution turns a red/brown colour
(b) Equation: $Zn_{(s)} + Cu^{2+}_{(aq)} \rightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$
Observation: metal turns black and then black coloured crystals grow on it.
Solution loses blue colour
(c) Equation: $2Na_{(s)} + 2H_2O_{(l)} \rightarrow 2Na^+_{(aq)} + 2OH^-_{(aq)} + H_{2(g)}$
Observation: silver coloured metal fizzes around on top of water, colourless, colourless gas produced
(d) Equation: $2MnO_4^-{}_{(aq)} + 5H_2O_{2(aq)} + 6H^+_{(aq)} \rightarrow 2Mn^{2+}_{(aq)} + 5O_{2(g)} + 8H_2O_{(l)}$
Observation: purple solution goes colourless and bubbles of colourless odourless gas produced

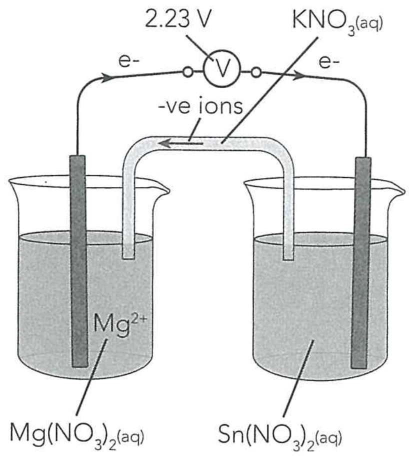
[12]

12.
(a)
(i) Oxidation $Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2e^-$
Reduction $2H^+_{(aq)} + 2e^- \rightarrow H^2_{(g)}$
(ii) Oxidation $Mg_{(s)} \rightarrow Mg^{2+}_{(aq)} + 2e^-$
Reduction $2H_2O_{(l)} + 2e^- \rightarrow 2OH^-_{(aq)} + H_{2(g)}$

(b)
(i) Oxidation $Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2e^-$
Reduction $(Ag^+_{(aq)} + e- \rightarrow Ag_{(s)}) \times 2$
Redox $Zn_{(s)} + 2Ag^+_{(aq)} \rightarrow Zn^{2+}_{(aq)} + Ag_{(s)}$
(ii) Oxidation $Mg_{(s)} \rightarrow Mg^{2+}_{(s)} + 2e-$
Reduction $Cl_{2(g)} \rightarrow 2Cl^-_{(s)}$
Redox $Mg_{(s)} + Cl_{2(g)} \rightarrow MgCl_{2(s)}$

[10]

13.



ANODE: $Mg \rightarrow Mg^{2+} + 2e^-$
CATHODE: $Sn^{2+} + 2e^- \rightarrow Sn$

[12]

14.
(a) Anode: $Fe \rightarrow Fe^{2+} + 2e^-$
Cathode: $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$
Rust formation: $2Fe(OH)_3 \rightarrow Fe_2O_3.H_2O + 2H_2O$

(b) (i) Coat the windmill with a paint to stop the oxygen and water coming in contact with the iron. This will prevent the cathodic reaction.
(ii) Connect another metal of higher oxidation potential to the windmill so that the iron acts as a cathode and the other metal an anode. For example if the other metal is zinc it will oxidise instead of the iron.

[12]

15.
(a)
(i) $(Fe_{(s)} \rightarrow Fe^{2+}_{(aq)} + 2e^-) \times 2$ anodic reaction
$O_{2(g)} + 2H_2O_{(l)} + 4e^- \rightarrow 4OH^-_{(aq)}$ cathodic reaction

$2Fe_{(s)} + O_{2(g)} + 2H_2O_{(l)} \rightarrow 2Fe(OH)_{2(s)}$

(ii) $4Fe(OH)_{2(s)} + 2H_2O_{(l)} + O_{2(g)} \rightarrow 4Fe(OH)_{3(s)}$
(iii) $2Fe(OH)_{3\,(s)} \rightarrow Fe_2O_3 . H_2O + 2H_2O_{(l)}$
(b) Any two of the following:
- Painting or plating the iron. This excludes air and/or water hence reaction prevented.
- Using a sacrificial anode such as galvanising

iron with zinc. The more reactive zinc will corrode in preference to the iron.

- *Using cathodic prevention by applying a low voltage to, say, a steel jetty. The power source provides a source of electrons in preference to the iron.*

[14]

TRIAL TEST 4: Organic Chemistry

Section 1

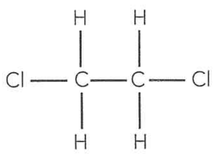
1. *a*	6. *a*
2. *d*	7. *c*
3. *c*	8. *d*
4. *b*	9. *c*
5. *d*	10. *d*

[20]

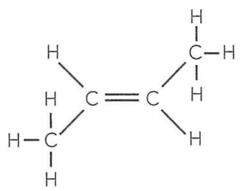
Section 2

11.
(a) cis-but-2-ene
(b) cis-2,2-dibromo-5-methylhept-3-ene
(c) pentan-2-one
(d) propanoic acid
(e) 6,7,7-tribromo-3,4-dichloroheptan-1-amine
(f) propylethanoate

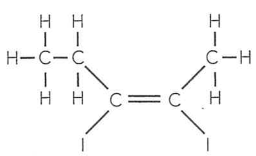
12.
(a)



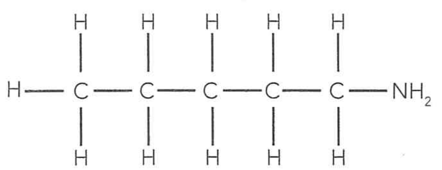
(b)



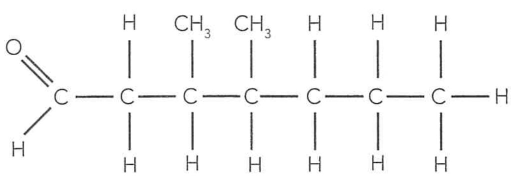
(c)



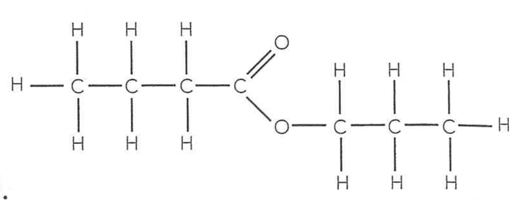
(d)



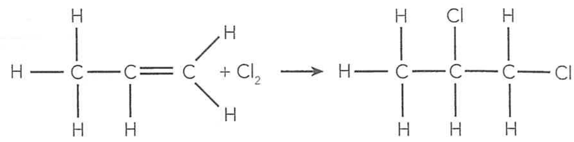
(e)



(f)

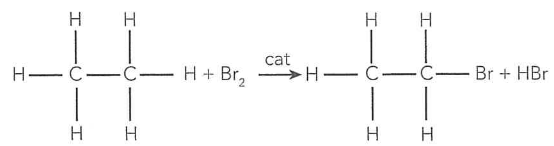


13.
(a)



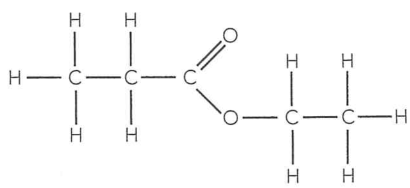
(b) $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$

(c)



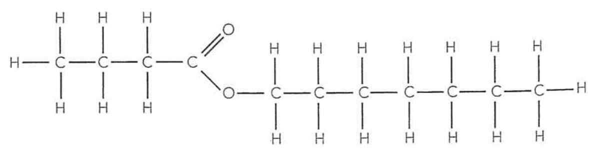
14.
(a) Oxidation: $CH_3CH_2CHO + H_2O \rightarrow CH_3CH_2COOH + 2H^+ + 2e^-$
Reduction: $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$
Redox: $3CH_3CH_2HO + Cr_2O_7^{2-}(aq) + 8H^+(aq) \rightarrow 3CH_3CH_2COOH(aq) + 2Cr^{3+}(aq) + 4H_2O(l)$
Name: *propanoic acid*
(b) Oxidation: $CH_3CHOHCH_2CH_3 \rightarrow CH_3COCH_2CH_3 + 2H^+ + 2e$
Reduction: $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$
Redox: $5CH_3CHOHCH_2CH_3 + 2MnO_4^-(aq) + 6H^+(aq) \rightarrow 5CH_3COCH_2CH_3 + 2Mn^{2+}(aq) + 8H_2O(l)$
Name: *butanone*

15.
(a)



ethyl propanoate

(b)



heptyl butanoate