ATAR CHEMISTRY – UNIT 3
TASK 7 – Oxidation and Reduction Test

TOTAL MARKS:

/35

NAME: ______________________

Answer all multiple choice answers on the slip of paper provided. Clearly write your short and extended answers in the space provided below. Where applicable show all working out and round final calculations to appropriate significant figures.

MULTIPLE CHOICE (6 marks)

1. Which one of the following pairs of statements is correct for both electrolysis cells and galvanic cells?

	Electrolysis Cell	Galvanic Cell
a)	Both electrodes are always inert.	Both electrodes are always made of metal.
b)	Electrical energy is converted to chemical energy.	The voltage of the cell is independent of the electrolyte concentration.
c)	Chemical energy is converted to electrical energy.	The products are dependent on the half-cell components.
d)	The products are dependent on the half-cell components.	Chemical energy is converted to electrical energy.

2. Which of the following statements about oxidising and reducing agents is false?

   a) Bromine water can oxidise chloride ions to chlorine.
   b) Hydrogen peroxide solution is capable of spontaneous self oxidation - reduction.
   c) Group I metals are good reducing agents.
   d) Copper metal will react with a dilute silver nitrate solution.

3. Four metals Pb, *x, y* and *z*, were connected in pairs and the voltage was recorded.

   The results obtained are set out in the table below.

Anode Cathode

Negative terminal	***Positive terminal***	***Voltage (V)***
Pb	*x*	0.35
y	Pb	1.10
z	Pb	2.60

   List the metals from **weakest** to the **strongest** reductant.

   a) *z*, *y*, Pb, *x*
   b) Pb, *x*, *y*, *z*
   c) *x*, *y*, Pb, *z*
   d) *x*, Pb, *y*, *z*

$X^{2+} + 2e^- \rightleftharpoons X$
$Pb^{2+} + 2e^- \rightleftharpoons Pb$
$Y^{2+} + 2e^- \rightleftharpoons Y$
$Z^{2+} + 2e^- \rightleftharpoons Z$

Inc. Reductant strength

4. Using the standard reduction potential table, which statement is correct?

   a) Sodium is more likely to be oxidised than zinc.

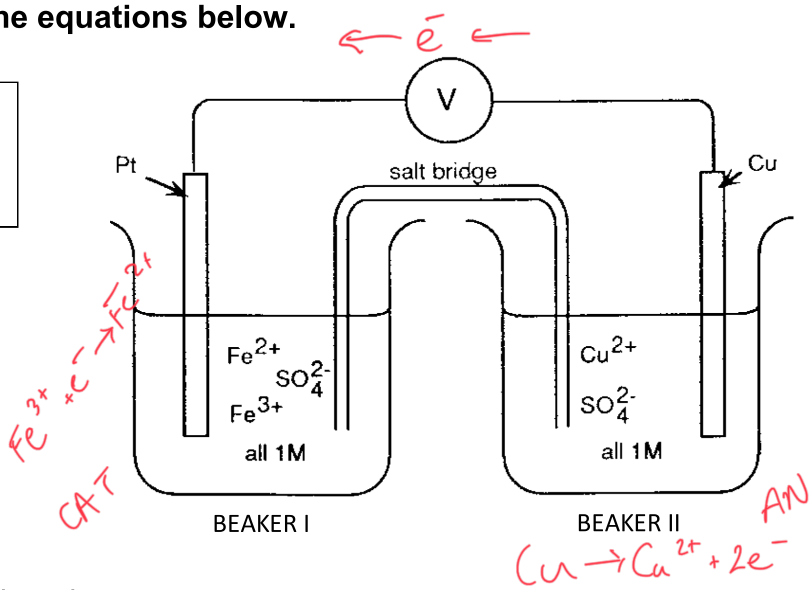
   b) Magnesium is more likely to be reduced than copper.

   c) Iron will react in a solution of magnesium nitrate.

   d) There will be a reaction if magnesium is placed in sodium nitrate.

Question 5 refers to the diagram and the equations below.

$Fe^{3+} + e^- \longrightarrow Fe^{2+}$	$E^0 = 0.77$ V
$Cu^{2+} + 2e^- \longrightarrow Cu$	$E^0 = 0.34$ V



5. If the salt bridge contained KNO_3 solution, the:

   a) K^+ ions move from beaker I and are replaced by Cu^{2+} ions.

   b) NO_3^- ions migrate into beaker I and are replaced by SO_4^{2-} ions from beaker II.

   c) K+ ions move into beaker II and NO_3^- ions move into beaker I.

   d) K^+ ions move into beaker I and NO_3^- ions move into beaker II.

6. A student made the following observations:

   (i) clean metal A did not react with 1.0M B^{2+}
   (ii) clean metal B dissolved in 1.0M C^{2+} and crystals of C appeared
   (iii) Clean metal C did not react with 1.0M A^{2+}

   The order of strength as a reducing agent is

   a) A > B > C

   b) A > C > B

   c) B > C > A

   d) B > A > C

$C^+ + e^- \rightarrow C$

$A^+ + e^- \rightarrow A$

$B^+ + e^- \rightarrow B$

SHORT ANSWER (13 marks)

1. Write any observations that would occur **after**:

(5 marks)

a) A strip of chromium metal is placed in a 1.00 $molL^{-1}$ solution of cobalt(ii) nitrate.

A shiny silver solid is placed in a pink solution. A new silver solid forms the pink solution changes to deep green. (2 marks)

b) Fluorine gas is bubbled into a solution of potassium chloride.

A yellow gas is bubbled into a colourless solution. Bubbles of a greenish-yellow gas form. (2 marks)

c) A piece of copper metal is placed in 2.00 $molL^{-1}$ hydrochloric acid.

A salmon pink solid is placed in a colourless solution, no visible reaction occurs. (1 mark)

2. Mo^{3+} can be oxidized by potassium permanganate under acidic conditions to produce the molybdate ion (MoO_4^{2-}). Manganese ions are also produce in the process.

a) Complete the table by writing balanced equations in the empty boxes.

(2 marks)

Oxidation Half-equation	$Mo^{3+} + 4H_2O \rightarrow MoO_4^{2-} + 8H^+ + 3e^-$ $(\times 5)$
Reduction Half-equation	$MnO^{4-}_{(aq)} + 8H^+_{(aq)} + 5e- \rightarrow Mn^{2+}_{(aq)} + 4H_2O_{(l)}$ $(\times 3)$
Overall Redox Reaction	$5Mo^{3+} + 8H_2O + 3MnO_4^- \rightarrow 3MoO_4^{2-} + 38H^+ + 3Mn^{2+}$

b) Use oxidation states to prove that the Mo^{3+} is being oxidized.

(1 mark)

$Mo^{3+} = +3$

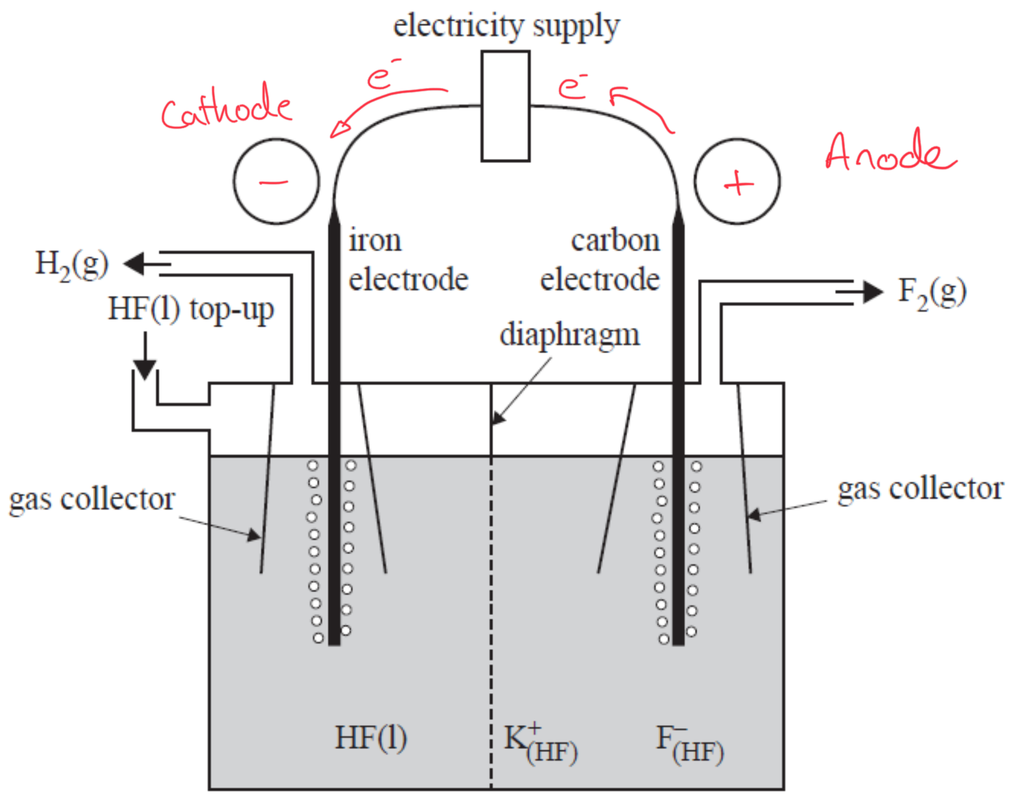
$MoO_4^{2-} = +6$

Mo goes from $+3 \rightarrow +6$ ∴ oxidation

3. Fluorine, F_2, gas is the most reactive of all non-metals. Anhydrous liquid hydrogen fluoride, HF, can be electrolysed to produce fluorine and hydrogen gases. Potassium fluoride, KF, is dissolved in the liquid HF to increase electrical conductivity.

F_2 is used to make a range of chemicals, including sulfur hexafluoride, SF_6, and excellent insulator, and xenon difluoride, XeF_2, a strong fluorination agent.

The diagram below shows an electrolytic cell used to prepare F_2 gas.



a) Label the polarities of each electrode in the circles provided on the diagram above.

(1 mark)

b) Write the equations for the half-reaction occurring at the anode.

(1 mark)

$2F^- \rightarrow F_2 + 2e^-$

c) Explain why the carbon electrode cannot be replaced with an iron electrode.

(3 marks)

1- Fe is more likely to oxidise/is more reactive/is a stronger reducing agent

1- It will therefore preferentially react/oxidise at the anode

1- The cell would produce very little F_2

Question 4 **(16 marks)**

The corrosion of iron and iron-containing structures is an ongoing and expensive problem. The subsequent rust that forms on an iron structure as a result of corrosion is flaky and weak. Rust not only changes the appearance of the iron, but decreases its strength. The consequences of this are wide ranging and diverse, and largely depend on the function of the iron structure.

The chemical processes occurring during the initial stage of iron corrosion can be represented by the half-equations below.

Cathode: $O_2(g) + 2\,H_2O(l) + 4\,e^- \rightarrow 4\,OH^-(aq)$

Anode: $Fe(s) \rightarrow Fe^{2+}(aq) + 2\,e^-$

(a) Prove, using oxidation numbers, that oxygen and water react at the cathodic site. (2 marks)

→ O atoms are reduced, oxidation number $0 \rightarrow -2$

→ Reduction occurs at the cathode

One common method which can prevent iron corrosion is the use of sacrificial anodes. These are often found in hot water tanks, where aluminium or zinc rods can be used to protect the iron tank.

In this situation, the cathode reaction remains the same, but the presence of a sacrificial anode prevents the iron from reacting.

(b) Explain why aluminium and zinc can be used as sacrificial anodes, but tin cannot. (3 marks)

- Aluminium and Zinc are stronger reducing agents / are more likely to oxidise
- This means they will corrode/oxidise/react preferentially to Fe
- Tin is a weaker reducing agent / is less likely to oxidise (so cannot be used as protection)

(c) Write a balanced chemical equation for the redox reaction occurring when an aluminium sacrificial anode is connected to the hot water tank. (2 marks)

$$4Al_{(s)} + 3O_{2(g)} + 6H_2O_{(l)} \rightarrow \underbrace{4Al^{3+}_{(aq)} + 12OH^-_{(aq)}}_{\text{accept } 4Al(OH)_{3(s)}}$$

1 - Correct species
1 - Correct balancing

(d) Calculate the number of years the hot water tank would be protected, before the aluminium rod would need replacing. Assume constant environmental conditions of 20.0 °C and 101.3 kPa. (5 marks)

Description			Marks
n(Al)	= =	545 / 26.98 20.2001 mol	1
$n(O_2$ consumed)	= =	(3 / 4) x 20.2001 15.1501 mol	1
$V(O_2$ consumed) =	= 364.507 L	(15.1501 x 8.314 x 293.15) / 101.3	1
Number of days =	= 1396.6 days	364.507 / 0.261	1
= =	1396.6 / 365 3.83 years protection		1
		Total	**5**
Note: award follow through marks based on incorrectly balanced equation in part (c).			

(e) If a sacrificial zinc anode, of the same mass, had been used instead, would this provide longer lasting protection for the hot water tank? Support your answer with appropriate calculations. (4 marks)

Description			Marks
n(Zn)	= =	545 / 65.38 8.3359 mol	1
$n(O_2$ consumed)	= =	(1 / 2) x 8.3359 4.1679 mol	1
$V(O_2$ consumed) =	= 100.279 L	(4.1679 x 8.314 x 293.15) / 101.3	1
Number of days =	= 384 days	100.279 / 0.261	1
		Total	**4**
Alternate working: The final two marks may be awarded for written conclusions, such as; • A smaller number of moles of O_2 is consumed using an equal mass of Zn • Therefore the Zn anode would not provide as long lasting protection			