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VCE Chemistry ¾
Introduction to Redox [0.5]
Workshop

Error Logbook:

Mistake/Misconception #1		Mistake/Misconception #2	
Question #:	Page #:	Question #:	Page #:
Notes:		Notes:	
Mistake/Misconception #3		Mistake/Misconception #4	
Question #:	Page #:	Question #:	Page #:
Notes:		Notes:	

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Section A: Recap (4 Marks)

Learning Objective: [1.6.1] – Apply Oxidation Numbers to Find Oxidant & Reductant

➤ Redox reactions must occur _____.

➤ Redox is the _____ of electrons- one substance gives away electrons, the other substance takes in electrons.

Oxidation Reaction	Reduction Reaction
Electrons are **[Gained]/[Lost].**	**Electrons** are **[Gained]/[Lost].**
Oxidation Number **[Increases]/[Decreases].**	Oxidation Number **[Increases]/[Decreases].**

➤ **Oxidation Number Rules**

    🔵 Isolated Elements (e.g., H_2):

    🔵 Ions (e.g., Na^+):

    🔵 Ionic Compounds (e.g., $NaCl$):

    🔵 Oxygen (O):

    🔵 Hydrogen (H):

    🔵 Sum of oxidation numbers in the compound is equal to (e.g., H_2SO_4 or MnO_4^-):

➤ **Oxidant**: Causes [reduction]/[oxidation] to other species, itself undergoes [reduction]/[oxidation].

➤ **Reductant**: Causes [reduction]/[oxidation] to other species, itself undergoes [reduction]/[oxidation].

➤ In conjugate redox pairs, the [oxidant]/[reductant] is always written first.

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Learning Objective: [1.6.2] – Apply KOHES to Write Balanced Half-Equations and Overall Equations in Acidic & Basic Conditions

➤ Balancing Equation Steps:

  ⟳ Balanced the _____.

  ⟳ Balanced the _____ by adding _____.

  ⟳ Balanced the _____ by adding _____.

  ⟳ Balanced the _____ by adding _____.

  ⟳ Included the _____.

➤ Acronym: _____.

➤ Balancing in Basic Conditions:

  1. Balance in _____ conditions first using KOHES.

  2. _____ hydrogen ions (H^+) by adding _____.

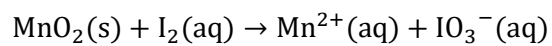➤ Number of electrons lost/gained should align with change in _____.

➤ Forming Overall Equation: Cancel out _____ by finding _____.

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Question 1 (4 marks) **Walkthrough.**

Balance the following equation in basic conditions:

$$MnO_2(s) + I_2(aq) \rightarrow Mn^{2+}(aq) + IO_3^{-}(aq)$$

_____

_____

_____

_____

_____

_____

_____

_____

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Section B: Warm Up (16 Marks)

INSTRUCTION: 16 Marks. 10 Minutes Writing.

Question 2 (2 marks)

For each of the following, answer True (T) or False (F):

	True	False
a. In an oxidation reaction, electrons are gained.		
b. In an oxidation reaction, the oxidation number increases.		
c. An oxidant undergoes reduction.		
d. If electrons are written on the right side of the half-equation, the reaction produces electrons, which means it is a reduction reaction.		

Question 3 (3 marks)

Find the oxidation number for the specified element in the following compounds:

a. Sulphur in SO_2. (0.5 marks)

b. Chromium in $K_2Cr_2O_7$. (0.5 marks)

c. Nitrogen in ammonium. (0.5 marks)

d. Carbon in oxalate ($C_2O_4{}^{2-}$). (0.5 marks)

e. Arsenic in As_2O_5. (0.5 marks)

f. Phosphorous in phosphoric acid. (0.5 marks)

Question 4 (3 marks)

Complete the balanced half-equations in **acidic** conditions, and state whether it is a reduction or oxidation reaction.

a. Liquid bromine turning into bromate (BrO_3^-). (1.5 marks)

_____

_____

_____

  Type of Reaction: [Reduction]/[Oxidation]

b. Sulphate turning into thiosulphate. (1.5 marks)

_____

_____

_____

  Type of Reaction: [Reduction]/[Oxidation]

Question 5 (3 marks)

Below is a balanced overall reaction:

$$4Zn(s) + NO_3^-(aq) + 10H^+(aq) \rightarrow 4Zn^{2+}(aq) + NH_4^+(aq) + 3H_2O(l)$$
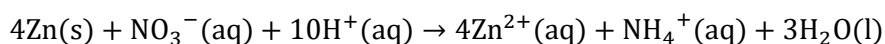
Reduction Equation: _____

Oxidation Equation: _____

Oxidant: _____   Reductant: _____

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Question 6 (5 marks)

a. Complete the balanced half-equations in **basic** conditions, and state whether it is a reduction or oxidation reaction.

   i. Iron (II) turning into iron (III). (1.5 marks)

   _____

   _____

   _____

   Type of Reaction: [Reduction]/[Oxidation]

   ii. Permanganate turning into manganese metal. (1.5 marks)

   _____

   _____

   _____

   Type of Reaction: [Reduction]/[Oxidation]

b. These two half-equations are combined to form an overall equation. Write the balanced reaction for the overall reaction. (2 marks)

   _____

   _____

   _____

   _____

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Section C: Ramping Up (16 Marks)
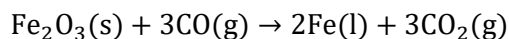
INSTRUCTION: 16 Marks. 12 Minutes Writing.

Question 7 (1 mark)

The oxidation number of Cl in $HClO_4$ is:

A. $+7$

B. $+5$

C. $+3$

D. -1

Question 8 (1 mark)

The equation for a reaction that occurs during the extraction of iron from iron ore is:

$$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(l) + 3CO_2(g)$$

During this reaction, the oxidation number of iron changes from:
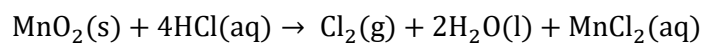
A. $+3$ to 0, and CO is the reductant.

B. $+6$ to 0, and CO is the reductant.

C. $+3$ to 0, and CO is the oxidant.

D. $+6$ to 0, and CO is the oxidant.

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The following information applies to the two questions that follow.

Consider the reaction:

$$MnO_2(s) + 4HCl(aq) \rightarrow Cl_2(g) + 2H_2O(l) + MnCl_2(aq)$$

Question 9 (1 mark)

The atoms whose oxidation numbers change during this reaction are:

A. Mn

B. Mn and Cl

C. Mn, Cl and O
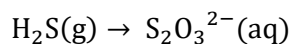
D. Mn, Cl, O and H

Question 10 (1 mark)

State the oxidant and the reductant for the above:

Oxidant	Reductant

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Question 11 (3 marks)

Jody is checking out hydrogen sulphide and how it can react like the following:

$$H_2S(g) \rightarrow S_2O_3^{2-}(aq)$$

a. Balance the following equation in basic conditions. (2 marks)

_____

_____

_____

b. Write the conjugate redox pair. (1 mark)

_____

Question 12 (5 marks)

a. Complete the balanced half-equations in **basic** conditions, and state whether it is a reduction or oxidation reaction. States are not required.

    i. Nitrate ions (NO_3^-) turning into nitrogen monoxide (NO). (1 mark)

_____

_____

_____

    Type of Reaction: [Reduction]/[Oxidation]

    ii. Copper turning into copper (II) ions. (1 mark)

_____

_____

_____

    Type of Reaction: [Reduction]/[Oxidation]

b. These two half-equations are combined to form an overall equation.

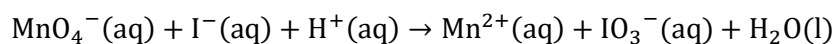   i. Write the balanced reaction for the overall reaction. (2 marks)

   _____

   _____

   _____

   _____

   ii. State the oxidant. (1 mark)

   _____

Question 13 (4 marks)

Balance the overall reaction for the following equation:

$$MnO_4^-(aq) + I^-(aq) + H^+(aq) \rightarrow Mn^{2+}(aq) + IO_3^-(aq) + H_2O(l)$$

   _____

   _____

   _____

   _____

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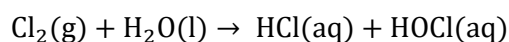
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Section D: Getting Trickier I (14 Marks)

INSTRUCTION: 14 Marks. 11 Minutes Writing.

Question 14 (1 mark)

Chlorine gas and water react according to the following equation:

$$Cl_2(g) + H_2O(l) \rightarrow HCl(aq) + HOCl(aq)$$

In this reaction, chlorine undergoes:

A. Oxidation only.

B. Reduction only.

C. Both oxidation and reduction.

D. Neither oxidation nor reduction.

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Question 15 (13 marks)

Several fuels can be combusted and used as an energy source in fuel cells.

a. Firstly, hydrogen gas is investigated.

    i. Write the balanced thermochemical equation for the combustion of hydrogen gas. (2 marks)

    ii. State the **conjugate oxidant** and the **conjugate reductant**. (1 mark)

    iii. Write out the two half-equations in a protonated environment. (2 marks)

    iv. Hence or otherwise, write the overall equation in the same environment. (1 mark)

b. Next, ethane gas is to be investigated.

    i. Write the balanced thermochemical equation for the complete combustion of ethane. (1 mark)

_____

    ii. Describe how electrons are transferred in this reaction, using **oxidation numbers** to aid your explanation. (2 marks)

_____

_____

_____

    iii. Write out the reduction half-equation in a high pH environment. (1.5 marks)

_____

_____

_____

    iv. Write out the oxidation half-equation in a high pH environment. (1.5 marks)

_____

_____

_____

    v. Hence or otherwise, write out the overall equation in the same environment. (1 mark)

_____

_____

_____

_____

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Section E: Getting Trickier II (11 Marks)

INSTRUCTION: 11 Marks. 10 Minutes Writing.

Question 16 (1 mark)

Which of the following reactions involves neither oxidation nor reduction?

A. $Fe(s) + Cu^{2+}(aq) \rightarrow Fe^+(aq) + Cu(s)$

B. $NH_4NO_2(s) \rightarrow N_2 + 2H_2O(g)$

C. $Cl_2(g) + H_2O(l) \rightarrow HCl(aq) + HOCl(aq)$

D. $Zn(OH)_2(s) + 2H^+(aq) \rightarrow Zn^{2+}(aq) + 2H_2O(l)$

Question 17 (10 marks)

Mia finds an interesting redox reaction involving chlorate turning into chlorine gas and perchlorate ions. Here is the unbalanced overall equation:

$$ClO_3^-(aq) \rightarrow Cl_2(g) + ClO_4^-(aq)$$
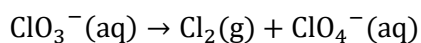
a. Find the change in oxidation number of chlorine in this reaction. (2 marks)

_____

_____

b. Hence, state the oxidant and reductant for this reaction. (1 mark)

_____

c.

    i. Write the balanced oxidation half-equation in **acidic** conditions. (1 mark)

_____

_____

    ii. Write the balanced reduction half-equation in **basic** conditions. (2 marks)

_____

_____

_____

d. Balance the overall equation in alkaline conditions. (2 marks)

_____

_____

_____

e. Write conjugate redox pairs for the **reverse** reaction. (2 marks)

_____

_____

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Section F: VCAA-Level Questions I (10 Marks)

INSTRUCTION: 10 Marks. 1 Minute Reading. 10 Minutes Writing.

Question 18 (6 marks)

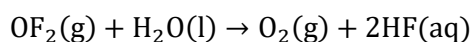One molecule to be investigated is oxygen difluoride, which has a molecular formula of OF_2.

a. State the oxidation number of oxygen in oxygen difluoride. (1 mark)

_____

_____

b. Oxygen difluoride reacts with water very slowly according to the following reaction:

$$OF_2(g) + H_2O(l) \rightarrow O_2(g) + 2HF(aq)$$

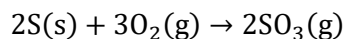**i.** Write the conjugate redox pairs for this reaction. (2 marks)

_____

_____

_____

ii. Write the balanced half-equation for the: (2 marks)

Reduction reaction: _____

Oxidation reaction: _____

c. Another reaction to be investigated is between sulphur and oxygen gas, as indicated below:

$$2S(s) + 3O_2(g) \rightarrow 2SO_3(g)$$

Identify whether the reaction is a redox reaction. Justify your answer. (1 mark)

_____

_____

_____

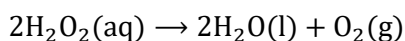**Question 19** (4 marks)

The following equation below depicts the decomposition of hydrogen peroxide to form water and oxygen gas:

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

a. Describe how the oxidation number of oxygen varies from the reactants to the products in the above reaction. (2 marks)

_____

_____

b. Hence or otherwise, write the:

i. Balanced half-equation for oxidation. (1 mark)

_____

ii. Balanced half-equation for reduction. (1 mark)

_____

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Section G: Multiple Choice Questions (10 Marks)

INSTRUCTION: 10 Marks. 9 Minutes Writing.

Question 20 (1 mark)

Inspired from VCAA Chemistry Exam 2015
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2015/2015chem-w.pdf

In which one of the following compounds is sulphur in its lowest oxidation state?

A. SO_3

B. HSO_4^-

C. SO_2

D. Al_2S_3

Question 21 (1 mark)

Which of the following could **not** be a product of the reduction of sulphuric acid when it acts as an oxidant?

A. S

B. H_2S

C. SO_2

D. $H_2S_2O_7$

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Question 22 (1 mark)

Which of the following statements is **incorrect**?

A. The oxidation number of C in HCHO is 0.

B. The oxidation number of Fe in Fe_3O_4 is $\frac{8}{3}$.

C. The oxidation number of O in OF_2 is -2.

D. The oxidation number of Cl in $Ba(ClO_3)_2$ is $+5$.

Question 23 (1 mark)

Iron can be readily oxidised in the presence of copper ions. The chemical equation is:

$$Fe(s) + Cu^{2+} \rightarrow Fe^{2+}(aq) + \underline{\hspace{2cm}}$$
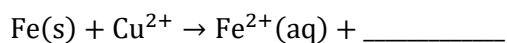
To complete this redox reaction, the missing chemical substance is:

A. $Cu^+(aq)$

B. $Cu(s)$

C. $Cu^{4+}(aq)$

D. $Cu^{3+}(aq)$

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Question 24 (1 mark)

Inspired from VCAA Chemistry Exam 2022
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2022/2022chem-w.pdf#page=6

The discharge reaction in a Vanadium redox battery is represented by the following equation:

$$VO_2^+(aq) + 2H^+(aq) + V^{2+}(aq) \rightarrow V^{3+}(aq) + VO^{2+}(aq) + H_2O(l)$$
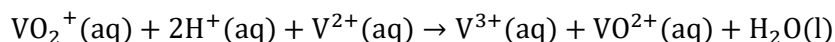
When the reverse of the redox reaction above is occurring:

A. H^+ is the reducing agent.

B. V^{3+} is the oxidising agent.

C. VO^{2+} is the reducing agent.

D. VO_2^+ is the oxidising agent.

Question 25 (1 mark)

The molar heat of combustion of glucose, $C_6H_{12}O_6$, in the cellular respiration equation is 2805 $kJ\ mol^{-1}$ at standard laboratory conditions (SLC).

Which one of the following statements about cellular respiration is correct?

A. Cellular respiration is an endothermic reaction.

B. The products of cellular respiration are carbon and carbon dioxide.

C. Cellular respiration is a redox reaction because $C_6H_{12}O_6$ accepts electrons from oxygen.

D. When one mole of oxygen is consumed in the reaction, 467.5 kJ of energy is released.

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Question 26 (1 mark)

Which of the following equations represents sulphur dioxide acting as an oxidant?

A. $Fe^{3+} + SO_2 + H_2O \rightarrow Fe^{2+} + SO_4^{2-} + H^+$

B. $Fe + SO_2 \rightarrow FeO + FeS$

C. $MnO_4^- + H_2O + SO_2 \rightarrow Mn^{2+} + H^+ + SO_3^-$

D. $Cr_2O_7^{2-} + H^+ + SO_2 \rightarrow Cr^{3+} + S_2O_6^- + H_2O$

The following information relates to the following two questions.

A cell that is popular in military use is the cell formed from the reaction of lithium and sulphur dioxide. The cell is expensive but is capable of producing a voltage of almost 3 volts. The overall equation for this cell is:

$$2Li + 2SO_2 \rightarrow Li_2S_2O_4$$
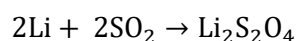
Question 27 (1 mark)

The half-equation for the oxidation reaction:

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

B. $2SO_2 + 2e^- \rightarrow S_2O_4^{2-}$

C. $SO_2 + 2OH^- + 2e^- \rightarrow S_2O_4^{2-}$

D. $SO_2 + O_2^- + 2e^- \rightarrow S_2O_4^{2-}$

Question 28 (1 mark)

In this reaction, the oxidation number of Sulphur:

A. Remains unchanged.

B. Changes from $+2$ to $+4$.

C. Changes from $+4$ to $+6$.
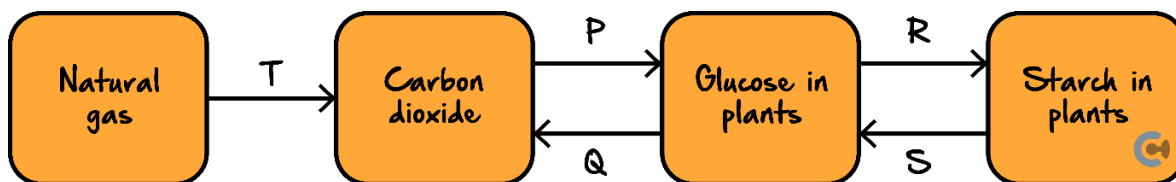
D. Changes from $+4$ to $+3$.

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Question 29 (1 mark)

Inspired from VCAA Chemistry Exam 2006
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2006chem1_w.pdf

A simplified section of the carbon cycle is shown below:

Carbon atoms are oxidised in the reaction(s):

A. Q only.

B. S and Q only.

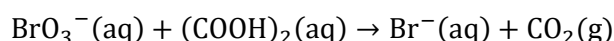**C.** Q and T only.

D. Q, R and T only.

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Section H: VCAA-Level Questions II (15 Marks)

Question 30 (6 marks)

The following **unbalanced** equation partially describes the process that occurs when potassium bromate solution, $KBrO_3$(aq), is mixed with a solution of oxalic acid, $(COOH)_2$(aq).

$$BrO_3{}^-(aq) + (COOH)_2(aq) \rightarrow Br^-(aq) + CO_2(g)$$

a.

   i. What is the oxidation number of bromine in $BrO_3{}^-$? (1 mark)

   _____

   ii. Give the formula of the species being oxidised. Explain your response. (1 mark)

   _____

   _____

b.

   i. Write the balanced oxidation half-equation. (1 mark)

   _____

   _____

   ii. Write the balanced reduction half-equation. (1 mark)

   _____

   _____

   iii. Write the balanced overall equation for the reaction. (1 mark)

   _____

   _____

c. As the reaction proceeds, does the solution become more or less acidic? Explain your answer. (1 mark)

_____

_____

Question 31 (9 marks)

Your friend at school who has just learnt about fuels refuses to believe that combustion can be classified as a redox reaction, but you, a Contour student, suggest that they are wrong.

a. Write the balanced equation for the incomplete combustion of ethanol to form carbon monoxide. (1 mark)

_____

b. Indeed, no electrons are present in the equation written in **part a.**, so your friend says that they are right and you have been taught incorrectly.

    i. Using oxidation numbers, explain how you are correct in that combustion is a redox reaction.
       (2 marks)

    _____

    _____

    ii. Now prove to your friend that electrons are present in the relevant balanced **half-equations** by writing them both out. You may assume acidic conditions. (2 marks)

    _____

    _____

    _____

    _____

c.

    i. For the half-equation containing the **oxidant**, state the conjugate redox pair and explain why the conjugate reductant is given such a name. (2 marks)

_____

_____

_____

    ii. For the **other** half-equation, explain the link between the species' change in oxidation number and the **number and position of electrons** in the half-equation. (2 marks)

_____

_____

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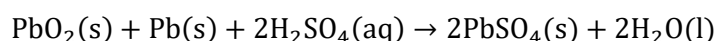## Section I: Extra Questions (9 Marks)

INSTRUCTION: 9 Marks. 10 Minutes Writing.

Question 32 (9 marks)

Car batteries, often known as lead-acid batteries, are comprised of two half-cells, which make up the entire cell.

a. If the overall equation occurring in a car battery is:

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

Which species must be the oxidant and which must be the reductant? Justify using oxidation numbers. (2 marks)

_____

_____

_____

b. Using the overall equation, write the two half-equations occurring at the two half-cells. (**Hint**: use $H_2SO_4(aq)$ as a reagent in both reactions.) (2 marks)

_____

_____

c. When the battery is recharging, the reverse reactions occur. Using relevant equation(s), explain why the recharge process is still considered to be classified as redox. (2 marks)

_____

_____

_____

_____

d. What is the new oxidant and the new reductant when the battery is charging? (1 mark)

_____

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e. Outline the link between your answers in **parts a.** and **d.** (1 mark)

_____

_____

f. You explain the chemistry of a car battery to a mechanic and they laugh and claim that according to your explanation, batteries would never need to be replaced; there would be an infinite cycle of charging and recharging. Suggest a possible reason as to why batteries do not last forever. (**Hint**: think about other redox reactions you might know). (1 mark)

_____

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Number for Text-Based Support
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