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VCE Chemistry ¾
Introduction to Redox [0.5]
Workshop Solutions

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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 ___exchange___ 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): 0
  - Ions (e.g., Na^+): charge
  - Ionic Compounds (e.g., $NaCl$): charge
  - Oxygen (O): -2
  - Hydrogen (H): $+1$
  - Sum of oxidation numbers in the compound is equal to (e.g., H_2SO_4 or MnO charge
- **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 ___Key element (not O or H)___.
  - Balanced the ___Oxygens___ by adding ___water (H_2O)___.
  - Balanced the ___Hydrogen___ by adding ___H^+___.
  - Balanced the ___charge___ by adding ___Electrons (e^-)___.
  - Included the ___States___.
- Acronym: ___KOHES___.
- Balancing in Basic Conditions:
  1. Balance in ___acidic___ conditions first using KOHES.
  2. ___Cancel out___ hydrogen ions (H^+) by adding ___hydroxide (OH^-)___.
- Number of electrons lost/gained should align with change in ___oxidation number___.
- Forming Overall Equation: Cancel out ___electrons___ by finding ___lowest common multiple___.

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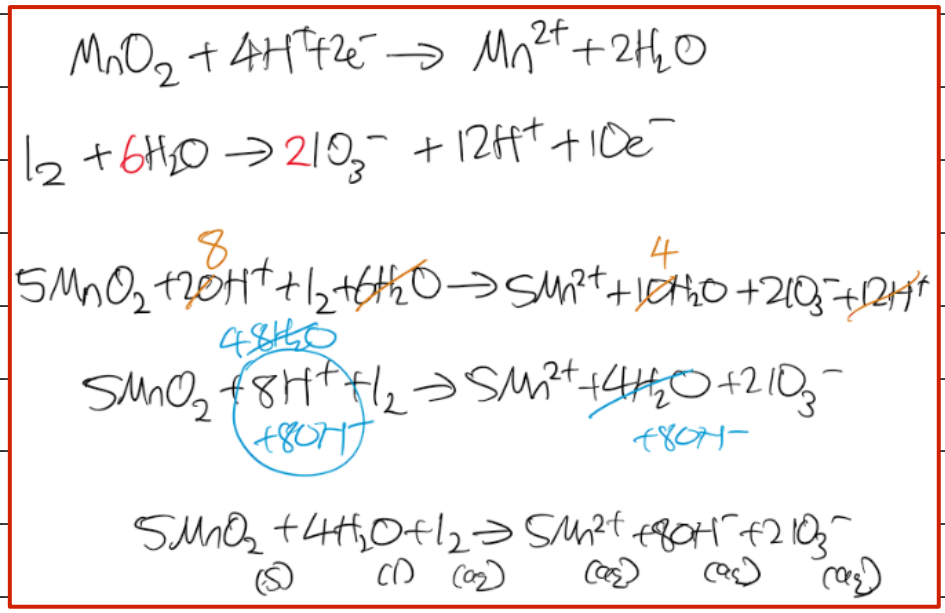
Question 1 (4 marks) **Walkthrough.**

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)

+4

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

+6

c. Nitrogen in ammonium. (0.5 marks)

−3

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

+3

e. Arsenic in As_2O_5. (0.5 marks)

−2

f. Phosphorous in phosphoric acid. (0.5 marks)

+5

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)

$$Br_2(l) + 6H_2O(l) \rightarrow 2BrO_3^-(aq) + 12H^+(aq) + 10e^-$$

Type of Reaction: [Reduction]/[Oxidation]

b. Sulphate turning into thiosulphate. (1.5 marks)

$$2SO_4^{2-} + 10H^+ + 10e^- \rightarrow S_2O_3^{2-} + 5H_2O$$

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: $NO_3^- + 10H^+ + 8e^- \rightarrow NH_4^+ + 3H_2O$

Oxidation Equation: $Zn \rightarrow Zn^{2+} + 2e^-$

Oxidant: NO_3^- Reductant: Zn

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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)

$$Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + e^-$$

Type of Reaction: [Reduction]/[Oxidation]

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

$$MnO_4^-(aq) + 4H_2O(l) + 7e^- \rightarrow Mn(s) + 8OH^-(aq)$$

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)

$$7Fe^{2+}(aq) + MnO_4^-(aq) + 4H_2O(l) \rightarrow 7Fe^{3+}(aq) + Mn(s) + 8OH^-(aq)$$

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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
MnO_2	HCl or Cl^-

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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)

$2H_2S + 3H_2O \rightarrow S_2O_3^{2-} + 10H^+ + 8e^-$

$2H_2S + 10OH^- \rightarrow S_2O_3^{2-} + 7H_2O + 8e^-$

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

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

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)

$NO_3^-(aq) + 2H_2O(l) + 3e^- \rightarrow NO(g) + 4OH^-(aq)$

Type of Reaction: [Reduction]/[Oxidation]

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

$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$

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)

$2NO_3^-(aq) + 4H_2O(l) + 3Cu(s) \rightarrow 3Cu^{2+}(aq) + 2NO(g) + 8OH^-(aq)$

ii. State the oxidant. (1 mark)

Nitrate

Question 13 (4 marks)

Balance the overall reaction for the following equation:

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

When balanced simply for atoms only, the chemical equation in the question doesn't balance the charges. So the transfer of electrons needs to be examined by balancing the equation using reduction and oxidation half-equations, leading to the overall equation:
$6MnO_4^-(aq) + 18H^+(aq) + 5I^-(aq) \rightarrow 6Mn^{2+}(aq) + 9H_2O(l) + 5IO_3^-(aq)$

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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)

$$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l) \quad \Delta H = -286\ kJ/mol$$

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

$H_2O(l)$ is both the conjugate oxidant and conjugate reductant.

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

$$H_2(g) \rightarrow 2H^+(aq) + 2e^-$$
$$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$$

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

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$$

b. Next, ethane gas is to be investigated.

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

$C_2H_6(g) + \frac{7}{2}O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l), \Delta H = -1560\ kJ/mol$

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

C goes from -3 to $+4$, and therefore is oxidised and loses electrons and allows O_2 to reduce, which gains electrons as its oxidation number goes down from 0 to -2.

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

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

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

$C_2H_6(g) + 14OH^-(aq) \rightarrow 2CO_2(g) + 10H_2O(l) + 14e^-$

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

$2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(l)$

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

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)

+5 to 0 **and** +5 to +7.

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

$ClO_3^{-}(aq)$ is both the oxidant and reductant.

c.

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

$ClO_3^-(aq) + H_2O(l) \rightarrow ClO_4^-(aq) + 2H^+(aq) + 2e^-$

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

$2ClO_3^-(aq) + 6H_2O(l) + 10e^- \rightarrow Cl_2(g) + 12OH^-(aq)$

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

$7ClO_3^-(aq) + H_2O(l) \rightarrow 5ClO_4^-(aq) + Cl_2(g) + 2OH^-(aq)$

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

$ClO_4^-(aq)/ClO_3^-(aq)$ and $ClO_3^-(aq)/Cl_2(g)$

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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)

$+2$

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)

$OF_2(g)/O_2(g)$
$O_2(g)/H_2O(l)$

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

Reduction reaction: $2OF_2(g) + 4e^- \rightarrow O_2(g) + 4F^-(aq)$

Oxidation reaction: $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$

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)

Yes, as there is a change in the oxidation number of sulfur from $0 \rightarrow +3$.

Question 19 (4 marks)

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

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

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

It decreases from -1 in H_2O_2 to -2 in water (1), whereas it increases from -1 to 0 in O_2 (2)

b. Hence or otherwise, write the:

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

$H_2O_2(aq) \rightarrow O_2(g) + 2H^+(aq) + 2e^-$

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

$H_2O_2(aq) + 2H^+(aq) + 2e^- \rightarrow 2H_2O(l)$

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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:

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

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	Correct answer	% A	% B	% C	% D	Comments
15	D	17	5	22	**55**	The equation for respiration is $C_6H_{12}O_6(aq) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$; $\Delta H = -2805\ kJ\ mol^{-1}$. This an exothermic redox reaction, in which $C_6H_{12}O_6$ is oxidised and so loses electrons. Oxidation number of carbon increases from an average of 0 to +4. The production of 2805 kJ of energy requires the consumption of 6 mol O_2, so when 1 mol O_2 is consumed 2805/6 = 467.5 kJ of energy is released.

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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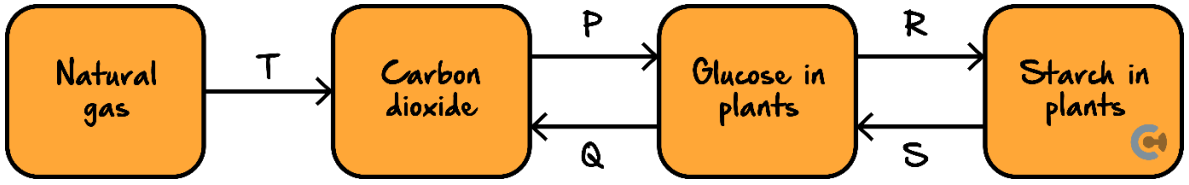
Question 29 (1 mark)

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.

9	12	21	56	11	The oxidation of natural gas (methane) in process T and glucose in process Q both involved a change in the oxidation state of carbon. Yet over 30% of students chose option A or B, which did not include process T.

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

INSTRUCTION: 15 Marks. 1 Minute Reading. 14 Minutes Writing.

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)

+5

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

$(COOH)_2$ C is oxidised from +3 to +4 state

b.

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

i. $(COOH)_2(aq) \rightarrow 2\,CO_2(g) + 2H^+(aq) + 2e^-$ 1 mark

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

ii. $BrO_3^-(aq) + 6H^+(aq) + 6e^- \rightarrow Br^-(aq) + 3\,H_2O(l)$ 1 mark

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

iii. $3(COOH)_2(aq) + BrO_3^-(aq) \rightarrow 6\,CO_2(g) + Br^-(aq) + 3\,H_2O(l)$ 1 mark

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

Less acidic- oxalic acid is being used up, and thus the amount of H^+ decreases.

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)

$C_2H_5OH(l) + 2O_2(g) \rightarrow 2CO(g) + 3H_2O(g/l)$

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)

O in O_2 goes from $0 \rightarrow -2$, therefore **reduction**/gain of e^-
And C in ethanol goes from -2 to $+2$ in CO, therefore loss of e^-**/oxidation.**

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)

$C_2H_5OH(l) + H_2O(l) \rightarrow 2CO(g) + 8H^+(aq) + 8e^-$ (1)
$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$ (2)

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)

$O_2(g)/H_2O(l)$
Called as such because if the reaction were going in **reverse (conjugate),** water would be a **reductant/would itself be oxidised**.

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)

C in ethanol goes from -2 to $+2$ in CO, therefore loss of e^-/oxidation → products side (1)

Change of 4 for each C, so $4e^-$ needed, but 2 C in ethanol, so $2 \times 4 = 8e^-$ (2)

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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)

$PbO_2(s)$ is the oxidant as Pb in PbO_2 goes from +4 to +2, meaning it has reduced.
Pb is the reductant as $Pb(s)$ goes from 0 to +2, meaning it has oxidised.

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)

$$PbO_2(s) + H_2SO_4(aq) + 2H^+(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$$
$$Pb(s) + H_2SO_4(aq) \rightarrow PbSO_4(s) + 2H^+(aq) + 2e^-$$

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)

$$PbSO_4(s) + 2H_2O(l) \rightarrow PbO_2(s) + H_2SO_4(aq) + 2H^+(aq) + 2e^-$$
$$PbSO_4(s) + 2H^+(aq) + 2e^- \rightarrow Pb(s) + H_2SO_4(aq)$$
These are the two new half-equations (the full equation is also valid as long as they explain how oxidation numbers change), **which still have reduction and oxidation occurring, but are flipped now.**

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

$PbSO_4$ is the new reductant **and** new oxidant (or Pb in $PbSO_4$).

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

The new oxidant in **d.** is the conjugate oxidant of the original reductant in **a.,** and the new reductant in **d.,** is the conjugate reductant of the original oxidant in **a.**

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)

The parts of a battery (electrodes) can rust/corrode, rendering them unusable after time or side reactions occur and over time, they can deteriorate the battery's parts.

Space for Personal Notes

CONTOUREDUCATION

Website: contoureducation.com.au | **Phone:** 1800 888 300 | **Email:** hello@contoureducation.com.au

VCE Chemistry ¾

Free 1-on-1 Support

Be Sure to Make The Most of These (Free) Services!

- Experienced Contour tutors (45+ raw scores, 99+ ATARs).
- For fully enrolled Contour students with up-to-date fees.
- After school weekdays and all-day weekends.

1-on-1 Video Consults	Text-Based Support
➢ Book via bit.ly/contour-chemistry-consult-2025 (or QR code below). ➢ One active booking at a time (must attend before booking the next).	➢ Message +61 440 137 304 with questions. ➢ Save the contact as "Contour Chemistry".

Booking Link for Consults
bit.ly/contour-chemistry-consult-2025

Number for Text-Based Support
+61 440 137 304