CH34 [0.5] - Introduction to Redox - Workshop

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CH34 [0.5] - Introducti...

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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: Key element $2H_2S \rightarrow S_2O_3^{2-}$		Notes: conj redox pair oxidant / reductant ClO_4^- / ClO_3^- more O	
Mistake/Misconception #3		**Mistake/Misconception #4**	
Question #:	Page #:	Question #: 18	Page #: 17
Notes: things can both reduce & oxidise oxidise: +5 $ClO_3^- \rightarrow$ +7 ClO_4^- reduce: $\rightarrow$ 0 Cl_2		Notes: OF_2 +2 more electronegative	

Section A: Recap (4 Marks)

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

- Redox reactions must occur in pairs.
- 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): periodic table
  - Oxygen (O): −2
  - Hydrogen (H): +1
  - Sum of oxidation numbers in the compound is equal to (e.g., H_2SO_4 or MnO_4^-) 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 Oxygen by adding H_2O.
  - Balanced the Hydrogen by adding H^+.
  - Balanced the charge by adding Electrons.
  - Included the States.
- Acronym: KOHES.
- Balancing in Basic Conditions:
  1. Balance in acidic conditions first using KOHES.
  2. neutralise hydrogen ions (H^+) by adding OH^- both sides.
- Number of electrons lost/gained should align with change in oxidation no.
- Forming Overall Equation: Cancel out electrons by finding LCM.

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

Balance the following equation in basic conditions: KOHES

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

$(MnO_2 + 4H^+ + 2e^- \rightarrow Mn^{2+} + 2H_2O) \times 5$

$I_2 + 6H_2O \rightarrow 2IO_3^- + 12H^+ + 10e^-$

$5MnO_2 + 20H^+ + I_2 + 6H_2O \rightarrow 5Mn^{2+} + 10H_2O + 2IO_3^- + 12H^+$

$5MnO_2 + 8H^+ + I_2 \rightarrow 5Mn^{2+} + 4H_2O + 2IO_3^-$
$+8OH^- \qquad +8OH^-$

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$5MnO_{2(s)} + 4H_2O_{(l)} + I_{2(aq)} \rightarrow 5Mn^{2+}_{(aq)} + 2IO_{3(aq)}^- + 8OH^-_{(aq)}$

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) Have No Fear Of Ice Cold Beer

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

a. Sulphur in SO_2. (0.5 marks)
(−2)2
+4

b. Chromium in $K_2Cr_2O_7$. (0.5 marks)
$Cr_2O_7^{2-}$
2(+1) (−2)7
+6

c. Nitrogen in ammonium. (0.5 marks)
NH_4^+ N+4(+1)=+1
N = 1−4
= −3

d. Carbon in oxalate ($C_2O_4^{2-}$). (0.5 marks)
2C+4(−2)=−2
2C=6
C=+3

e. Arsenic in As_2O_3. (0.5 marks)
2As+5(−2)=0
2As=10
As=+5

f. Phosphorus in phosphoric acid. (0.5 marks)
$H_3PO_4 \rightarrow PO_4^{2-}$
3(+1)+P+4(−2)=0
P=8−3=+5

Question 4 (3 marks) Phosphoric acid (H_3PO_4)

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)

$2SO_{4(aq)}^{2-} + 10H^+_{(aq)} + 8e^- \rightarrow S_2O_{3(aq)}^{2-} + 5H_2O_{(l)}$

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: $NO_{3(aq)}^- + 10H^+_{(aq)} + 8e^- \rightarrow NH_{4(aq)}^+ + 3H_2O_{(l)}$

Oxidation Equation: $Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2e^-$

Oxidant: $NO_{3(aq)}^-$ Reductant: $Zn_{(s)}$

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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)

$(Fe^{2+}_{(aq)} \rightarrow Fe^{3+}_{(aq)} + e^-) \times 7$

Type of Reaction: [Reduction]/[✓ Oxidation]

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

$MnO_{4(aq)}^- + 8H^+ + 7e^- \rightarrow Mn_{(s)} + 4H_2O_{(l)}$
$+8OH^- \qquad +8OH^-$

$MnO_{4(aq)}^- + 4H_2O_{(l)} + 7e^- \rightarrow Mn_{(s)} + 8OH^-_{(aq)}$

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:
+1 −8
+7

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:

reduces
oxidant: +3 −2 +2 −2 0 +4 −2

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

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:

oxidises
+4 −2 +1 −1 0 +1 −2 +2 −1

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

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
$MnO_{2(s)}$	$HCl_{(aq)}$

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Question 11 (3 marks)

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

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

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

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

oxidation: $2H_2S_{(g)} + 10OH^-_{(aq)} \rightarrow S_2O_{3(aq)}^{2-} + 7H_2O_{(l)} + 8e^-$

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

$S_2O_{3(aq)}^{2-} / H_2S_{(g)}$

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)

$NO_3^- + 4H^+ + 3e^- \rightarrow NO + 2H_2O$
$+4OH^- \qquad +4OH^-$

$(NO_{3(aq)}^- + 2H_2O_{(l)} + 3e^- \rightarrow NO_{(g)} + 4OH^-_{(aq)}) \times 2$

Type of Reaction: [✓ Reduction]/[Oxidation]

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

$(Cu_{(s)} \rightarrow Cu^{2+}_{(aq)} + 2e^-) \times 3$

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)

$NO_{3(aq)}^-$

Question 13 (4 marks)

Balance the overall reaction for the following equation:

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

$(MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O) \times 6$

$(I^- + 3H_2O \rightarrow IO_3^- + 6H^+ + 6e^-) \times 5$

$6MnO_4^- + 48H^+ + 5I^- + 15H_2O \rightarrow 6Mn^{2+} + 24H_2O + 5IO_3^- + 30H^+$

$6MnO_{4(aq)}^- + 18H^+_{(aq)} + 5I^-_{(aq)} \rightarrow 6Mn^{2+}_{(aq)} + 9H_2O_{(l)} + 5IO_{3(aq)}^-$

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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:

reduces oxidises
0 −1 +1

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

In this reaction, chlorine undergoes:

A. Oxidation only.
B. Reduction only.
C. Both oxidation and reduction. ✓
D. Neither oxidation nor reduction.

red $Cl_2 \rightarrow HCl$
oxid $Cl_2 \rightarrow HOCl$

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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)

$H_2O_{(l)}$ for both

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)

$C_2H_{6(g)} + \frac{7}{2}O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(l)} \quad \Delta H = -1560\ kJ/mol$

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

C goes from +3 → +4, & thus is loss from C which means it undergoes oxidation. The e^- are given to O_2 which goes from 0 → −2 & undergoes reduction.

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)

$C_2H_{6(g)} + \frac{7}{2}O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(l)}$

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

+5 → 0
+5 → +7

$$ClO_3^-(aq) \rightarrow Cl_2(g) + ClO_4^-(aq)$$

a. Find the change in oxidation number of chlorine in this reaction. (2 marks)

$ClO_3^- \rightarrow Cl_2$ +5 → 0 (−5)
$ClO_3^- \rightarrow ClO_4^-$ +5 → +7 (+2)

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

$ClO_{3(aq)}^-$ is both oxidant/reductant

c.

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

$(ClO_{3(aq)}^- + H_2O_{(l)} \rightarrow ClO_{4(aq)}^- + 2H^+_{(aq)} + 2e^-) \times 5$

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

$2ClO_3^- + 12H^+ + 10e^- \rightarrow Cl_2 + 6H_2O$
$+12OH^- \qquad +12OH^-$

$2ClO_{3(aq)}^- + 6H_2O_{(l)} + 10e^- \rightarrow Cl_{2(g)} + 12OH^-_{(aq)}$

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

$5ClO_3^- + 5H_2O + 2ClO_3^- + 6H_2O \rightarrow 5ClO_4^- + 10H^+ + Cl_2 + 12OH^-$

$7ClO_{3(aq)}^- + H_2O_{(l)} \rightarrow 5ClO_{4(aq)}^- + Cl_{2(g)} + 2OH^-_{(aq)}$

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

$ClO_{3(aq)}^- / Cl_{2(g)}$

$ClO_{4(aq)}^- / ClO_{3(aq)}^-$

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

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

O−F
F −2

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) KOHES

Reduction reaction: $2OF_{2(g)} + 4e^- \rightarrow O_{2(g)} + 4F^-_{(aq)}$

Oxidation reaction: $2H_2O_{(l)} \rightarrow O_{2(g)} + 4H^+_{(aq)} + 4e^-$

KOHES

$2OF_2 + 2H_2O \rightarrow 2O_2 + 4HF$

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, there is a change in oxidation no.
S: 0 → +3
O: 0 → −2

H−O−O−H (−1)

Question 19 (4 marks)

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

−1 → −2, 0

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

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

For $H_2O_2 \rightarrow H_2O$ −1 → −2
For $H_2O_2 \rightarrow O_2$ −1 → 0

KOHES

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)

$2H^+_{(aq)} + H_2O_{2(aq)} + 2e^- \rightarrow 2H_2O_{(l)}$

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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 +6
B. HSO_4^- +6 +1+4(−2)+S=−1 S=+6
C. SO_2 +4
D. Al_2S_3 −2 ✓

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?

H_2SO_4 +6

A. S 0
B. H_2S −2
C. SO_2 +4
D. $H_2S_2O_7$ ✓

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+8/3 +3 +3 +2 Fe Fe Fe

Question 22 (1 mark)

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

A. The oxidation number of C in HCHO is 0. 2(+1)−2=0
B. The oxidation number of Fe in Fe_3O_4 is $\frac{8}{3}$. 3Fe+4(−2)=0 3Fe=8 Fe=8/3
C. The oxidation number of O in OF_2 is [illegible] +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:

+2 reduce

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

0 +2 −2e⁻

To complete this redox reaction, the missing chemical substance is:

A. $Cu^+(aq)$ +1
B. Cu(s) 0 ✓
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:
+2 +3 oxidation +4

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)

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O \quad \Delta H = -2805\ kJ/mol$

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. $Fe^{3+} + SO_2 + H_2O \rightarrow Fe^{2+} + SO_4^{2-} + H^+$ +4 +6
B. $Fe + SO_2 \rightarrow FeO + FeS$ +4 → −2 ✓
C. $MnO_4^- + H_2O + SO_2 \rightarrow Mn^{2+} + H^+ + SO_3^-$ +4 +5
D. $Cr_2O_7^{2-} + H^+ + SO_2 \rightarrow Cr^{3+} + S_2O_6^{2-} + H_2O$ +4 +5

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:

$$2Li + 2SO_2 \rightarrow Li_2S_2O_4$$

0 +4 +1 $S_2O_4^{2-}$
2S+4(−2)=−2
2S=6
S=+3

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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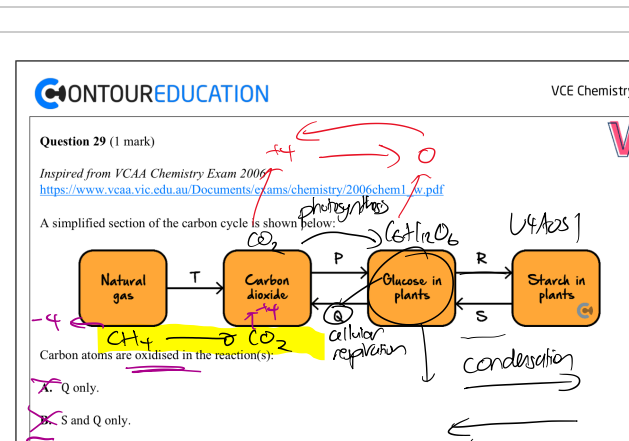
Question 29 (1 mark)

Inspired from VCAA Chemistry Exam 2006
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2006/chem1_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. R and T only. ✓
D. Q, R and T only.

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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)

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)

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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VCE Chemistry ¾
Free 1-on-1 Consults

What Are 1-on-1 Consults?

- **Who Runs Them?** Experienced Contour tutors (45 + raw scores and 99 + ATARs).
- **Who Can Join?** Fully enrolled Contour students.
- **When Are They?** 30-minute 1-on-1 help sessions, after-school weekdays, and all-day weekends.
- **What To Do?** Join on time, ask questions, re-learn concepts, or extend yourself!
- **Price?** Completely free!
- **One Active Booking Per Subject:** Must attend your current consultation before scheduling the next :)

SAVE THE LINK, AND MAKE THE MOST OF THIS (FREE) SERVICE!

Booking Link

bit.ly/contour-chemistry-consult-2025