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VCE Chemistry ¾
Spontaneous Redox Reactions [1.7]
Homework

Homework Outline:

Compulsory Questions	Pg 02 - Pg 15
Supplementary Questions	Pg 16 - Pg 26

Section A: Compulsory Questions (42 Marks)

Sub-Section [1.7.1]: Apply the ECS to Predict Spontaneous Reactions

Question 1 (3 marks)

Write the (i) oxidation and (ii) half equations for each of the following spontaneous reactions.

a. John reacts zinc metal (Zn) with copper (II) sulphate ($CuSO_4$) in aqueous solution.

i. Oxidation half equation. (0.5 marks)

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ii. Reduction half equation. (0.5 marks)

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b. Maggie reacts copper metal (Cu) with silver nitrate ($AgNO_3$) in aqueous solution.

i. Oxidation half equation. (0.5 marks)

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ii. Reduction half equation. (0.5 marks)

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c. Ivy reacts nickel sulphate ($NiSO_4$) with hydrogen gas (H_2).

i. Oxidation half equation. (0.5 marks)

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ii. Reduction half equation. (0.5 marks)

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Question 2 (3 marks)

Write the (i) oxidation and (ii) half equations for each of the following spontaneous reactions.

a. Esther reacts tin (II) sulphate ($SnSO_4$) with iron (III) phosphate ($FePO_4$) in an aqueous solution.

i. Oxidation half equation. (0.5 marks)

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ii. Reduction half equation. (0.5 marks)

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b. Angel reacts hydrogen peroxide (H_2O_2) with iodide ions (KI) in an aqueous solution.

i. Oxidation half equation. (0.5 marks)

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ii. Reduction half equation. (0.5 marks)

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c. Cherry reacts hydrogen gas (H_2) with tin (II) sulphate ($SnSO_4$) in an aqueous environment.

i. Oxidation half equation. (0.5 marks)

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ii. Reduction half equation. (0.5 marks)

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Space for Personal Notes

Question 3 (6 marks)

Write the (i) oxidation and (ii) half equations for each of the following spontaneous reactions.

a. Ethan reacts a solution of potassium permanganate ($KMnO_4$), iron (II) sulphate ($FeSO_4$), and hydrogen peroxide (H_2O_2) in aqueous medium.

i. Oxidation half equation. (1 mark)

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ii. Reduction half equation. (1 mark)

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b. Olivia reacts tin (II) chloride ($SnCl_2$) with a mixture of iron (III) nitrate ($Fe(NO_3)_3$) and copper (II) iodide (CuI_2) in an aqueous solution.

i. Oxidation half equation. (1 mark)

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ii. Reduction half equation. (1 mark)

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c. Lucas reacts copper (II) nitrate ($Cu(NO_3)_2$) with zinc (Zn), silver nitrate ($AgNO_3$), and hydrochloric acid (HCl) in solution.

i. Oxidation half equation. (1 mark)

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ii. Reduction half equation. (1 mark)

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Sub-Section [1.7.2]: Identify Differences Between Direct & Indirect Redox Reactions, & Features of ECS

Question 4 (3 marks)

Michelle adds hydrogen peroxide (H_2O_2) into water (H_2O). She observes no physical signs of a chemical reaction occurring.

a. Predict two physical indicators that Michelle may be looking for to suggest that a reaction is occurring. (2 marks)

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b. Justify why no chemical reaction is occurring. (1 mark)

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Question 5 (2 marks)

Melody adds a strip of lead (Pb) to a beaker containing a 1.0 M aqueous solution of silver sulphate (Ag_2SO_4).

a. Predict the half-reactions occurring in the beaker.

i. Oxidation reaction. (0.5 marks)

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ii. Reduction reaction. (0.5 marks)

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b. State the type of energy conversion occurring in this chemical reaction. (1 mark)

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Question 6 (2 marks)

State the primary difference between direct contact and indirect contact spontaneous redox reactions.

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Sub-Section [1.7.3]: Find the Strongest Oxidants/Reductants by Constructing Your Own ECS

Question 7 (4 marks)

a. Three unknown substances P, Q, and R are present. The half equations are provided without $E°$ values.

Reaction
$P^{2+}(aq) + 2e^- \rightleftharpoons P(s)$
$Q^{2+}(aq) + 2e^- \rightleftharpoons Q(s)$
$R^{2+}(aq) + 2e^- \rightleftharpoons R(s)$

The following facts are known:

- When P reacts with a solution of R^{2+}, a reaction occurs.
- When Q interacts with a solution of P^{2+}, the beaker containing the solution becomes warmer.

Rank the three metals in decreasing oxidant strength. (2 marks)

b. Three unknown substances X, Y, and Z are present. The half equations are provided without $E°$ values.

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

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

$$Z^{2+}(aq) + 2e^- \rightarrow Z(g)$$

The following observations are recorded:

- When Z^{2+} is added to Y, no bubbles are produced.
- When Z^{2+} is added to X, the beaker containing the solutions becomes warmer.

Rank the substances in increasing reductant strength. (2 marks)

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Question 8 (2 marks)

a. Four unknown substances A, B, C, and D are present. The half-equations are provided without $E°$ values.

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

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

$$C^{3+}(aq) + 3e^- \rightarrow C(g)$$

$$D^{+}(aq) + e^- \rightarrow D(l)$$

The following observations are recorded:

- When C^{3+} is added to A, the reaction mixture fizzes (produces gas bubbles).
- When D^{+} is added to A^{2+}, no reaction occurs.
- When C^{3+} is added to B, the solution releases heat.

Rank the four substances in decreasing oxidant strength. (2 marks)

b. Four unknown substances A, B, C, and D are present. The half-equations are provided without $E°$ values.

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

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

$$C^{3+}(aq) + 3e^- \rightarrow C(s)$$

$$D^{+}(aq) + e^- \rightarrow D(g)$$

The following observations are recorded:

- When B^+ is added to A^{2+}, no reaction occurs.
- When C^{3+} is added to A, the temperature of the beaker increases.
- When D^+ is added to B, gas bubbles are observed.

Rank the four substances in increasing reductant strength. (2 marks)

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Question 9 (6 marks)

a. A scientist is given five metals and 1 *M* solution of nitrates of the metals.

The metals are labelled M, N, O, P and Q and the solutions are labelled M^{2+}, N^{2+}, O^{2+}, P^{2+}, and Q^{2+}.

The student carries out a number of experiments and the results obtained are listed below:

i. Metal O began to be coated in different metals when placed in solutions of M^{2}, N^{2+}, and P^{2+} but not Q^{2+}.

ii. A solution of P^{2+} underwent a reaction when metal M was dipped in it.

iii. Metal N is known to be the weakest reductant.

Rank each of the 5 metals in order of decreasing $E°$ values. (3 marks)

b. A scientist is given five metals and 1 *M* solution of nitrates of the metals.

The metals are labelled M, N, O, P, and Q and the solutions are labelled M^{2+}, N^{2+}, O^{2+}, P^{2+}, and Q^{2+}.

The student carries out a number of experiments and the results obtained are listed below:

i. When metal Q is dipped in all solutions, it reacts vigorously with all of them.

ii. When a metal rod of N is dipped in all solutions, it only begins to degrade in M^{2+} and O^{2+} solutions.

iii. M^{2+} reacts vigorously when reacted with metal O.

Rank each of the 5 metals in order of decreasing $E°$ values. (3 marks)

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Sub-Section: The 'Final Boss'

Question 10 (9 marks)

Ivy is investigating the following reactions shown below.

1. $ClO_2^-(aq) + 2H^+(aq) + e^- \rightarrow ClO(g) + H_2O(l)$
2. $Sn^{4+}(aq) + 2e^- \rightarrow Sn^{2+}(aq)$
3. $BrO_3^-(aq) + 6H^+(aq) + 6e^- \rightarrow Br_2(l) + 3H_2O(l)$
4. $NO_3^-(aq) + 4H^+(aq) + 3e^- \rightarrow NO_2(g) + 2H_2O(l)$

She notes down the following observations:

- When BrO_3^- is mixed with $ClO(g)$, a reaction occurs, and bubbles are produced.
- NO_3^- reacts with Sn^{2+}, generating heat but no gas.
- When ClO_2^- is added to Sn^{2+}, no observable reaction occurs.
- Br_2 reacts with NO_2, releasing a small amount of heat.

a. Rank the 4 substances in increasing oxidant strength. (2 marks)

b. Using **part a.**, predict whether a reaction will occur when $BrO_3^-(aq)$ is mixed with $Sn^{2+}(aq)$. Justify your answer. (2 marks)

c. Explain why no observable reaction takes place when $ClO_2^-(aq)$ is mixed with $NO_2(g)$. (2 marks)

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d. All the oxidants and reductants from the above reactions are added to a reaction vessel.

i. Write the overall equation for the reaction occurring immediately, as soon as the reagents are added to the vessel. (2 marks)

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ii. State the energy conversions occurring during this reaction. (1 mark)

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Section B: Supplementary Questions (34 Marks)

Sub-Section [1.7.1]: Apply the ECS to Predict Spontaneous Reactions

Question 11 (3 marks)

Write the (i) oxidation and (ii) half equations for each of the following spontaneous reactions.

a. Sarah reacts magnesium metal (Mg) with hydrochloric acid (HCl) in an aqueous solution.

i. Oxidation half equation. (0.5 marks)

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ii. Reduction half equation. (0.5 marks)

_____

b. Liam reacts aluminium metal (Al) with iron (III) chloride ($FeCl_3$) in aqueous solution.

i. Oxidation half equation. (0.5 marks)

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ii. Reduction half equation. (0.5 marks)

_____

c. Emma reacts lead (II) nitrate ($Pb(NO_3)_2$) with solid zinc (Zn).

i. Oxidation half equation. (0.5 marks)

_____

ii. Reduction half equation. (0.5 marks)

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Question 12 (3 marks)

Write the (i) oxidation and (ii) half equations for each of the following spontaneous reactions.

a. Rebecca reacts tin (II) chloride ($SnCl_2$) with iron (III) nitrate ($Fe(NO_3)_3$) in an aqueous solution.

i. Oxidation half equation. (0.5 marks)

_____

ii. Reduction half equation. (0.5 marks)

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b. Kevin reacts hydrogen peroxide (H_2O_2) with permanganate ions (MnO_4^-) in an aqueous solution.

i. Oxidation half equation. (0.5 marks)

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ii. Reduction Half equation. (0.5 marks)

_____

c. Chloe reacts hydrogen gas (H_2) with tin (II) nitrate ($Sn(NO_3)_2$) in an aqueous environment.

i. Oxidation half equation. (0.5 marks)

_____

ii. Reduction half equation. (0.5 marks)

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Space for Personal Notes

Question 13 (4 marks)

Write the (i) oxidation and (ii) half equations for each of the following spontaneous reactions.

a. Sophia adds tin (II) chloride ($SnCl_2$) to a solution containing potassium dichromate ($K_2Cr_2O_7$) and hydrogen peroxide (H_2O_2) in aqueous conditions.

i. Oxidation half equation. (1 mark)

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_____

ii. Reduction half equation. (1 mark)

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b. Angela adds iron (III) chloride ($FeCl_3$), hydrogen peroxide (H_2O_2), and sulphuric acid (H_2SO_4) in aqueous medium.

i. Oxidation half equation. (1 mark)

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ii. Reduction half equation. (1 mark)

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Question 14 (2 marks)

Vivek is given the following electrochemical series for some reactions that are not occurring at SLC.

$Sn^{4+}(aq) + 2e^- \rightleftharpoons Sn^{2+}(aq)$	$+0.1$
$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$	$+0.25$
$I_2(s) + 2e^- \rightleftharpoons 2I^-(aq)$	$+0.69$
$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$	-0.90

Vivek adds copper (II), iodide and tin (IV) ions to a beaker. Following this, he adds a strip of zinc metal.

Predict the half equations of the reaction occurring.

a. Oxidation reaction. (1 mark)

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b. Reduction reaction. (1 mark)

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Sub-Section [1.7.2]: Identify Differences Between Direct & Indirect Redox Reactions, & Features of ECS

Question 15 (4 marks)

Betty is analysing a reaction between oxygen gas (O_2) and iron metal (Fe).

a. State and justify using chemical equations whether the reaction is spontaneous. (2 marks)

b. When Betty sets up this reaction in the laboratory, she notices no reaction occurring. Provide a justification for this observation. (1 mark)

c. Provide a physical application of this chemical reaction. (1 mark)

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Question 16 (2 marks)

Precious adds a strip of magnesium (Mg) to a beaker containing a 1.0 *M* aqueous solution of aluminium phosphate ($AlPO_4$).

a. Predict the half-reactions occurring in the beaker.

i. Oxidation reaction. (0.5 marks)

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ii. Reduction reaction. (0.5 marks)

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b. State the type of energy conversion occurring in this chemical reaction. (1 mark)

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Question 17 (2 marks)

State the role of the Standard Hydrogen Electrode (SHE) in the electrochemical series.

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Question 18 (3 marks)

Discuss the limitations of the electrochemical series when applied to real-world chemical reactions.

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Sub-Section [1.7.3]: Find the Strongest Oxidants/Reductants by Constructing Your Own ECS

Question 19 (4 marks)

a. There are three unknown substances J, K, and L. The following half-equations are given, but their $E°$ values are not given.

Reaction
$J^{2+}(aq) + 2e^- \rightarrow J(s)$
$K^{2+}(aq) + 2e^- \rightarrow K(s)$
$L^{2+}(aq) + 2e^- \rightarrow L(s)$

It is known that when J is mixed into a solution of L^{2+}, a reaction begins to occur.

It is also known that when K is mixed into a solution of L^{2+}, no reaction occurs.

Rank the three metals in terms of their decreasing oxidant strength. (2 marks)

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b. There are three unknown substances A, B, and C. The following half-equations are given, but their $E°$ values are not given.

Reaction
$A^{2+}(aq) + 2e^- \rightarrow A(s)$
$B^{2+}(aq) + 2e^- \rightarrow B(s)$
$C^{2+}(aq) + 2e^- \rightarrow C(s)$

i. A plastic rod coated in metal A reacts vigorously with a solution of $B(NO_3)_2$ and CSO_4.

ii. Metal C is able to react with B^{2+} but not with A^{2+}.

Rank the three metals in terms of their decreasing oxidant strength. (2 marks)

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Question 20 (3 marks)

Four unknown substances P, Q, R, and S are present. The half-equations are provided without $E°$ values.

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

$$Q^{+}(aq) + e^- \rightarrow Q(g)$$

$$R^{3+}(aq) + 3e^- \rightarrow R(s)$$

$$S^{+}(aq) + e^- \rightarrow S(l)$$

The following observations are recorded:

1. When Q^+ is added to P^{2+}, no reaction occurs.
2. When R^{3+} is added to P, the beaker becomes warmer.
3. When S^+ is added to Q, gas bubbles are observed.

Rank the four substances in increasing reductant strength.

Space for Personal Notes

Question 21 (4 marks)

A scientist is given five metals and 1 *M* solutions of their nitrates.

The metals are labelled A, B, C, D, and E and the solutions are labelled A^{2+}, B^{2+}, C^{2+}, D^{2+}, and E^{2+}.

The scientist carries out several experiments, and the results obtained are as follows:

1. When metal A is dipped into all solutions, it reacts vigorously with D^{2+} and E^{2+}, but no reaction occurs with B^{2+} or C^{2+}.
2. When metal D is dipped into all solutions, it reacts only with E^{2+}.
3. Metal C, when dipped into solutions, reacts with B^{2+} but not with A^{2+}.
4. B^{2+} reacts with metal E, but no reaction occurs when B^{2+} is added to C.

a. State the strongest oxidant and reductant. (2 marks)

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b. Rank the metals in terms of decreasing $E°$ values. (2 marks)

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