CH34 [0.6] - Spontaneous Redox Reactions - Workshop

Sunday 26 January 2025 5:49 PM

CH34 [0.6] - Spontaneo...

CONTOUREDUCATION

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VCE Chemistry ¾

Spontaneous Redox Reactions [0.6]

Workshop

9 day

Tues → 6:45–8:45

Error Logbook:

Mistake/Misconception #1		Mistake/Misconception #2	
Question #: 15	Page #: 15	Question #: 13	Page #: 13
Notes: H_2O is always present (if weak oxidant/reductant, sus it out)		Notes: Strong reductant w/ ticks ↳ strongest reductant has most ticks	
Mistake/Misconception #3		**Mistake/Misconception #4**	
Question #: 22 24	Page #: 24 25	Question #:	Page #:
Notes: If some chem are also in ECS, use that to your advantage		Notes:	

7:10

Section A: Recap (5 Marks)

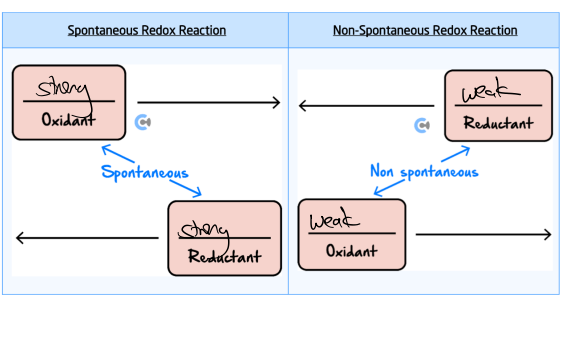
Learning Objective: [1.7.1] - Apply the ECS to Predict Spontaneous Reactions

- Net Ionic Equation Definition: A balanced full equation with spectator ions omitted.
- Spectator Ion: Compound which is present but does not react.

Reduction Reaction	Oxidation Reaction
[✓ Forward] / [Reverse] reaction on ECS.	[Forward] / [✓ Reverse] reaction on ECS.

Oxidants	Reductants
Positioned on the [✓ left] / [right] side.	Positioned on the [left] / [✓ right] side.

Strongest Oxidants	Strongest Reductants
Positioned [✓ top] / [bottom] - [✓ left] / [right].	Positioned [top] / [✓ bottom] - [left] / [✓ right].



- Steps to predicting spontaneous reaction: ~~$ZnSO_4$~~
  1. Split all species into cations/anions. Some cations/anions are inert.
  2. Locate all species on the ECS. Draw a vertical line to splits oxidants and reductants apart.
  3. Draw a mini ECS.
  4. Find the strongest oxidant and strongest reductant.
  5. Check for negative/downhill gradient.
  6. Write out half-equations.
- When multiple oxidants/reductants are present, the strongest oxidant reacts with strongest reductant.
- The four ions which appear on both sides of the electrochemical series:
  - Fe^{2+}
  - Sn^{2+}
  - Pb^{2+}
  - Mn^{2+}

Question 1 (3 marks) **Walkthrough.**

Some copper metal ($Cu_{(s)}$) is dipped into a solution which contains copper nitrate, tin (II) nitrate, zinc chloride and aluminium bromide.

Cu^{2+} NO_3^- Sn^{2+} Zn^{2+} Cl^-

Find the overall reaction which takes place.

$Cu^{2+} + 2e^- \rightarrow Cu$

$Sn^{2+} \rightarrow Sn^{4+} + 2e^-$

$Cu^{2+}_{(aq)} + Sn^{2+}_{(aq)} \rightarrow Cu_{(s)} + Sn^{4+}_{(aq)}$

	Cl^-
	Br^-
Cu^{2+}	Cu
	Sn^{2+}
Sn^{2+}	
Zn^{2+}	
Al^{3+}	

Learning Objective: [1.7.2] - Identify Differences Between Direct & Indirect Redox Reactions & Features of ECS

- Standard Electrode Potential Definition: Method to measure EMF.
- Standard Hydrogen Electrode (SHE): $H^+(aq)/H_2(g)$, which has E^0 = 0V.
- The electrochemical series does not predict the rate of reaction.

Direct Contact Spontaneous Redox Reaction	Indirect Contact Spontaneous Redox Reaction
chemical → thermal	chemical → electric

Learning Objective: [1.7.3] - Find Strongest Oxidants/Reductants by Constructing Your Own ECS

- Electrochemical series ordered from [lowest → highest] / [✓ highest → lowest] E^0 value.

Strongest Oxidant	Strongest Reductant
[✓ Highest] / [Lowest] E^0 value.	[Highest] / [✓ Lowest] E^0 value.

- Creating electrochemical series yourself steps:
  1. Draw a vertical line to separate oxidants and reductants.
  2. Using information, place oxidants/reductants on this mini electrochemical series.

Spontaneous Reactions	Non-Spontaneous Reactions
[Positive] / [✓ Negative] gradient.	[✓ Positive] / [Negative] gradient.

  3. Write the conjugate version of the oxidant/reductant.
  4. Repeat for each piece of information.

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Question 2 (2 marks) **Walkthrough.**

There are three unknown substances, P, Q and R. The following half-equations are given, but their E^0 values are not given.

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

It is known that when P is mixed into a solution of R^{2+}, no observable reaction occurs.

It is also known that when Q is mixed into a solution containing R^{2+}, no observable reaction occurs.

When S and Q^{2+} are combined, a reaction occurs.

When S^{2+} and P are combined, a reaction occurs.

Rank the three metals in terms of their decreasing oxidant strength.

- Decreasing oxidant strength: $Q^{2+}_{(aq)}$, $S^{2+}_{(aq)}$, $P^{2+}_{(aq)}$, $R^{2+}_{(aq)}$

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Q^{2+}	Q
S^{2+}	S
P^{2+}	P
R^{2+}	R

Section B: Warm Up (13.5 Marks)

INSTRUCTION: 13.5 Marks. 9 Minutes Writing.

Question 3 (0.5 marks)

What is the strongest reductant out of the following chemicals?

$Fe^{3+}, Sn^{2+}, H_2O, K^+, Br^-, Au, Pb^{2+}$

$Sn^{2+}_{(aq)}$

Question 4 (2 marks)

Cobalt (II) nitrate has cadmium metal dipped inside of it.

a.

i. Write the reduction reaction which takes place. (0.5 marks)

$Co^{2+}_{(aq)} + 2e^- \rightarrow Co_{(s)}$

ii. Write the oxidation reaction which takes place. (0.5 marks)

$Cd_{(s)} \rightarrow Cd^{2+}_{(aq)} + 2e^-$

b. Write the **full balanced ionic equation**. (1 mark)

$Co^{2+}_{(aq)} + Cd_{(s)} \rightarrow Cd^{2+}_{(aq)} + Co_{(s)}$

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Question 5 (3 marks)

For each of the following, determine whether a reaction will occur or not. If there is a reaction, write the relevant reduction and oxidation reactions.

a. A solid nickel rod (Ni) dipped into a solution containing tin (II) nitrate. (1 mark)

Reaction is [✓ Spontaneous] / [Non-Spontaneous]

$Sn^{2+}_{(aq)} + 2e^- \rightarrow Sn_{(s)}$

$Ni_{(s)} \rightarrow Ni^{2+}_{(aq)} + 2e^-$

b. A solution containing hydrofluoric acid (HF) is mixed with a strip of calcium metal. (1 mark)

Reaction is [✓ Spontaneous] / [Non-Spontaneous]

$2H^+_{(aq)} + 2e^- \rightarrow H_{2(g)}$

$Ca_{(s)} \rightarrow Ca^{2+}_{(aq)} + 2e^-$

c. A solution containing iron (II) nitrate and zinc metal. (1 mark)

Reaction is [✓ Spontaneous] / [Non-Spontaneous]

$Fe^{2+}_{(aq)} + 2e^- \rightarrow Fe_{(s)}$

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

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Question 6 (3 marks)

A solution of iron (III) fluoride has a nickel rod placed inside of it.

a. Write the half-reactions which take place: (2 marks)

Reduction: $(Fe^{3+} + e^- \rightarrow Fe^{2+}) \times 2$

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

b. Write the overall reaction which takes place. (1 mark)

$2Fe^{3+}_{(aq)} + Ni_{(s)} \rightarrow 2Fe^{2+}_{(aq)} + Ni^{2+}_{(aq)}$

Question 7 (1 mark)

~~Solution I - 1.0 M NaCl~~

Solution II - 1.0 M $CuCl_2$

~~Solution III - 1.0 M $MgCl_2$~~

Which solution or solutions above will react with Zn powder?

A. Solution I only.

[✓ B.] Solution II only.

C. Solutions I and III only.

D. Solutions I, II and III.

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Question 8 (4 marks)

The following half-equations are given:

$C^{2+}(aq) + 2e^- \rightleftharpoons C(s)$ +1.21 V

$B^{2+}(aq) + 2e^- \rightleftharpoons B(s)$ − 0.89 V

$A^{2+}(aq) + 2e^- \rightleftharpoons A(s)$ + 1.35 V

$D^{2+}(aq) + 2e^- \rightleftharpoons D(s)$ + 1.12 V

A^{2+}	A
C^{2+}	C
D^{2+}	D
B^{2+}	B

a. State the weakest oxidant and the weakest reductant.

Weakest Oxidant	Weakest Reductant
$B^{2+}_{(aq)}$	$A_{(s)}$

a. A solution of $B^{2+}(aq)$ is mixed with some D(s). Will a reaction occur? Explain why/why not, and if there is a reaction, write the overall reaction which takes place. (2 marks)

No as B^{2+} is a weak oxidant, D is a weak reductant relative to each other.

b. A solution of $A^{2+}(aq)$ is mixed with some C(s). Will a reaction occur? Explain why/why not, and if there is a reaction, write the overall reaction which takes place. (2 marks)

Yes, as A^{2+} is a strong oxidant, C is a strong reductant relative to each other.

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Section C: Ramping Up (11 Marks)

INSTRUCTION: 11 Marks. 8 Minutes Writing.

Question 9 (1 mark)

Some strips of the metals, iron, zinc and silver were placed in separate beakers, each containing 1.0 M nickel (II) sulfate solution in water at 25°C.

What is expected to occur over time?

A. Ni will be deposited in all of the beakers.

B. Ni will not be deposited in any of the beakers.

C. A reaction will occur only in the beakers containing Ag.

[✓ D.] A reaction will occur only in the beakers containing Fe and Zn.

Question 10 (2 marks)

A solution containing silver bromide is mixed with a solution of tin (II) chloride.

State whether a reaction will occur or not. If yes, write the overall reaction which takes place. If not, explain why no reaction will occur.

Yes

$Ag^+_{(aq)} + e^- \rightarrow Ag_{(s)}$ $Sn^{2+}_{(aq)} \rightarrow Sn^{4+}_{(aq)} + 2e^-$

$2Ag^+_{(aq)} + Sn^{2+}_{(aq)} \rightarrow Sn^{4+}_{(aq)} + 2Ag_{(s)}$

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Question 11 (6 marks)

A solution of iron (II) nitrate was placed in a beaker with Ag_2SO_4.

a.

i. Write the reduction half-equation. (1 mark)

$Ag^+_{(aq)} + e^- \rightarrow Ag_{(s)}$

ii. Write the oxidation half-equation. (1 mark)

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

iii. Hence, write the overall equation. (1 mark)

$Ag^+_{(s)} + Fe^{2+}_{(aq)} \rightarrow Ag_{(s)} + Fe^{3+}_{(aq)}$

b. It is then noted that the beaker has a very high pH. Would this realisation have any effect on the reaction(s) taking place? Explain your answer, writing any relevant half-equations to justify your answer. (2 marks)

basic OH^-

Yes as OH^- is present which is a stronger reductant than Fe2+

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

c. If, instead of Ag_2SO_4, the beaker had $CdSO_4$, outline what effect this would have on the reaction(s) taking place. (1 mark)

No Reaction occurs as Cd2+ is a much weaker oxidant and will not be strong enough to oxidise the Fe2+

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Question 12 (2 marks)

Nethaya is similarly given five metals and 1 M solutions of nitrates of the metals.

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 student carries out several experiments and the results obtained are listed below.

- Metal A reacts with B^{2+} spontaneously.
- Metal C becomes coated with another metal when placed in each of solutions A^{2+}, B^{2+}, D^{2+}, but not with E^{2+}.
- When metal A is dipped into a solution of D^{2+}, no reaction takes place.

Rank each of the 5 metals in order of increasing E^0 values.

1. B^{2+}	B
2. A^{2+}	A
3. D^{2+}	D
4. C^{2+}	C
5. E^{2+}	E

- Increasing E^0 values: $E_{(s)}, C_{(s)}, D_{(s)}, A_{(s)}, B_{(s)}$

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Section D: Getting Trickier I (12 Marks)

INSTRUCTION: 12 Marks. 10 Minutes Writing.

Question 13 (1 mark)

Samples of four metals (W, X, Y and Z) were each placed in separate solutions containing the cations W^{2+}, X^{2+} and Y^{2+}. If a reaction occurred, a tick was placed in the appropriate cell of the results table shown below.

		Metal			
		W	X	Y	Z
Solution	W^{2+}			✓	✓
	X^{2+}	✓		✓	✓
	Y^{2+}				✓

Which of the following shows the metals in order of **decreasing** reductant strength?

[✓ A.] Z, Y, W, X

B. Y, W, X, Z

C. X, W, Y, Z

D. Z, X, W, Y

Z, Y, W, X

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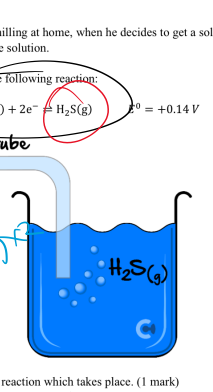
Question 14 (4 marks)

Johann, who is a bored Contour student, is chilling at home, when he decides to get a solution of iron (III) chloride and bubbles hydrogen sulphide (H_2S) into the solution.

Hydrogen sulphide can react according to the following reaction:

$S(s) + 2H^+(aq) + 2e^- \rightleftharpoons H_2S(g)$ $E^0 = +0.14$ V



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

a. Write the half-equation for the oxidation reaction which takes place. (1 mark)

$H_2S_{(g)} \rightarrow S_{(s)} + 2H^+_{(aq)} + 2e^-$

b.

more acidic

i. Write the balanced equation for the overall reaction which takes place. (1 mark)

$2Fe^{3+}_{(aq)} + H_2S_{(g)} \rightarrow 2Fe^{2+}_{(aq)} + S_{(s)} + 2H^+_{(aq)}$

ii. Write the balanced equation for the overall reaction which takes place in alkaline conditions. (1 mark)

$2Fe^{3+}_{(aq)} + H_2S_{(g)} + 2OH^-_{(aq)} \rightarrow 2Fe^{2+}_{(aq)} + S_{(s)} + 2H_2O_{(l)}$

c. As the reaction takes place, explain how the pH will change as the reaction proceeds. (1 mark)

pH↓, H^+ is produced, more acidic

Question 15 (7 marks)

Lithium-ion batteries are becoming very commonplace and useful to society. Lithium can oxidise into Li^+, but a major issue is that Li is an extremely reactive metal.

Siggy, who does not study VCE chemistry, suggests to her friend, Nishi, to simply react Li with something random to oxidise it into the desired Li^+. Nishi naively decides to place Li in a solution of aluminium hydroxide, and a violent explosion is observed.

a. Write the two half-equations for this reaction. (2 marks)

$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$

$(Li_{(s)} \rightarrow Li^+_{(aq)} + e^-) \times 2$

b. Hence, write the overall equation. (1 mark)

$2LiOH_{(aq)}$

$2H_2O_{(l)} + 2Li_{(s)} \rightarrow H_{2(g)} + 2OH^-_{(aq)} + 2Li^+_{(aq)}$

c. With reference to specific chemicals, explain why an explosion is observed. (2 marks)

H_2 is produced which is flammable. It reacts with oxygen in the air according to the following: $H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)}$

d. If a strong oxidant such as $Ag^+(aq)$ were to be reacted with lithium metal, would the desired lithium ions be produced safely? Justify your answer. (2 marks)

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$Li_{(s)}$ Ag^+ Ag^+ Ag^+ Ag^+

Section E: Getting Trickier II (13 Marks)

INSTRUCTION: 13 Marks. 12 Minutes Writing.

Question 16 (1 mark)

A student reacted 4 metals (A, B, C and D) with 1 M solutions of their corresponding ion. A table of results was set up with a tick placed against any reaction that occurred.

Metal/Solution	A^{2+}	B^+	C^{2+}	D^{3+}
A	▨		✓	✓
B	✓	▨	✓	✓
C			▨	✓
D				▨

The strongest reductant and weakest oxidant respectively are:

A. B and B^+.

B. D and D^{3+}.

C. B and D^{3+}.

D. D and B^+.

The strongest reductant is B as it is oxidised by all of the solutions.
The weakest oxidant is B+ as it is reduced by none of the reductants.

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Question 17 (5 marks)

Renee wants to test her chemistry and thus decided to bubble fluorine gas into a solution of silver (I) chloride.

a. State the strongest oxidant and reductant present. (1 mark)

Strongest reductant: SR: $H_2O(l)$

Strongest oxidant: SO: $F_2(g)$

b. Write the half-equations which take place. (2 marks)

Reduction half-equation: $F_2(g) + 2e^- \rightarrow 2F^-(aq)$

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

c.

i. Bubbles are observed as the reaction takes place. Explain this observation with reference to the products formed. (1 mark)

$O_2(g)$ is produced as water is oxidised (a lot of students will erroneously say $Cl_2(g)$)

ii. List another possible observation. (1 mark)

Decrease in pH as $H^+(aq)$ is produced.

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Question 18 (7 marks)

Stainless steel items are very popular in the hospitality industry. Steel is made up mostly of iron, carbon, and small amounts of cobalt and manganese.

a.

i. If a steel pan were to be filled with water, would a reaction be expected to occur? Justify your answer. (2 marks)

Yes, as the oxidant (H_2O) is higher on the ECS than the strongest reductant (Mn).

ii. Why is a reaction often not observed in practice? (1 mark)

Rate of reaction is too slow.

b.

i. Now a mixture of $ZnSO_4(aq)$ and $Ni(NO_3)_2(aq)$ solutions are tossed into the steel pan. Write the overall equation taking place. (1 mark)

$Ni^{2+}(aq) + Mn(s) \rightarrow Ni(s) + Mn^{2+}(aq)$

ii. If the $Ni(NO_3)_2(aq)$ runs out after some time, causing another reaction to take place. Write the half-equation for the new reaction which takes place. Explain your answer. (2 marks)

Zn^{2+} is now strongest oxidant so it would react with Mn(s):
$Zn^{2+}(aq) + Mn(s) \rightarrow Zn(s) + Mn^{2+}(aq)$

iii. After a prolonged time, both the $Ni(NO_3)_2(aq)$ and the Mn(s) in the steel pan ran out. Explain what would be observed to occur now. (1 mark)

Reactions would cease as strongest oxidant ($Zn^{2+}(aq)$) is lower on ECS than strongest reductant (Fe(s)).

Let's take a BREAK!

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Section F: VCAA-Level Questions I (13 Marks)

INSTRUCTION: 13 Marks. 30 Seconds Reading. 12 Minutes Writing.

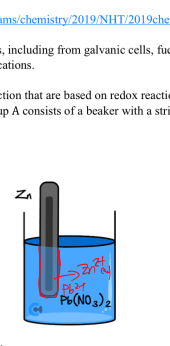
Question 19 (13 marks)

Inspired from VCAA Chemistry Exam 2019
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2019/NHT/2019chem-nht-w.pdf#page=24

Energy can be produced in a variety of ways, including from galvanic cells, fuel cells and gas-fired power stations. Each of these methods suits particular applications.

Galvanic cells are methods of energy production that are based on redox reactions, similar to the reaction that would occur in Set-up A shown below. Set-up A consists of a beaker with a strip of Zinc, Zn, in a solution of lead (II) nitrate, $Pb(NO_3)_2$.

Set-up A



a. For the reaction which occurs in set-up A,

$Pb^{2+} \rightarrow Pb_{(s)}$

i. Identify the oxidising agent. (1 mark)

$Pb^{2+}_{(aq)}$, $Pb(NO_3)_{2(aq)}$

ii. Write the oxidation half-equation for this reaction. (1 mark)

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

iii. Provide the location of the two products for this system. (1 mark)

$Zn^{2+}_{(aq)}$: into solution/water

$Pb_{(s)}$: on/coat on strip of zinc

① both

b. Due to the transfer of electrons in this reaction, identify:

i. The sign of change in chemical enthalpy of the system. (1 mark)

exothermic (negative) (−)

ii. The energy transformations. (1 mark)

chemical to thermal

c. State the specific properties of reactants present in this system that allow a reaction to occur and explain why this is the case. State any assumptions made in using the electrochemical series to predict the reactions occurring in this example. (3 marks)

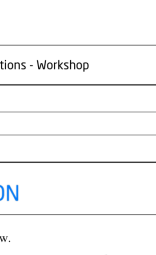
① Pb2+ is a relatively strong oxidant, Zn(s) is a relatively strong reductant relative to each other.

As a result, a spontaneous reaction can occur between them without any external input of energy.

① The reactants can also be in contact with each other as the solid is submerged into the aqueous solution, allowing exchange of electrons.

① Assumptions made is that the reactions are occurring at SLC and 1.0 M, as those are the conditions in which the electrochemical series are constructed at.

A similar setup to **part a.** is shown below.



All substances are placed together simultaneously in an already acidic environment which leads to the heating of the beaker.

The $Cr_2O_7^{2-}(aq)/Cr^{3+}(aq)$ conjugate redox pair is known to have an E^0 value of +1.36 V.

The $SO_4^{2-}(aq)/SO_3^{2-}(aq)$ is known to have a E^0 value of − 0.94 V.

d. As they mix together, a reaction begins to occur.

i. Write the half-equations which occur for (2 marks)

Reduction: $Cr_2O_7^{2-}{}_{(aq)} + 14H^+_{(aq)} + 6e^- \rightarrow 2Cr^{3+}_{(aq)} + 7H_2O_{(l)}$

Oxidation: $(SO_3^{2-}{}_{(aq)} + H_2O_{(l)} \rightarrow SO_4^{2-}{}_{(aq)} + 2H^+_{(aq)} + 2e^-) \times 3$

ii. Write the overall reaction which occurs. (1 mark)

$Cr_2O_7^{2-}{}_{(aq)} + 8H^+_{(aq)} + 3SO_3^{2-}{}_{(aq)} \rightarrow 2Cr^{3+}_{(aq)} + 4H_2O_{(l)} + 3SO_4^{2-}{}_{(aq)}$

$H_2Cr_2O_7 + 3H_2SO_3$ $Cr_2(SO_4)_3$

e. The primary reductant is measured and observed to have run out, however, a reaction keeps occurring, leading to a decrease in pH. Write the overall equation that occurs. (2 marks)

reduction: $(Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O) \times 2$

oxidation: $(2H_2O \rightarrow O_2 + 4H^+ + 4e^-) \times 3$

overall: $2Cr_2O_7^{2-}{}_{(aq)} + 16H^+_{(aq)} \rightarrow 4Cr^{3+}_{(aq)} + 3O_{2(g)} + 8H_2O_{(l)}$

Section G: Multiple Choice Questions (7 Marks)

INSTRUCTION: 7 Marks. 7 Minutes Writing.

The following information relates to the next two questions.

A number of experiments were conducted using various metals (Zn, Cu, Cr and Cd) and solutions of their ions. The results are shown in the table below.

$Cu^+_{(aq)} + e^- \rightleftharpoons Cu_{(s)}$

Experiment	Result
Cadmium and copper (I) nitrate solution.	Copper metal deposited.
Cadmium and zinc nitrate solution.	No reaction.
Chromium and cadmium nitrate solution.	Cadmium metal deposited.

Question 20 (1 mark)

From the results in the table, the relative reducing strength of three of the metals can be deduced. Beginning with the weakest reductant, the order of increasing reductant is:

A. Cd < Zn < Cr

B. Cu < Cr < Cd

C. Zn < Cd < Cu

[✓ D.] Cu < Cd < Cr

Cu^+	Cu
Cd^{2+}	Cd
	Cr
Zn^{2+}	Zn
	Cr

Question 21 (1 mark)

Which additional experiment must be conducted to place all four metals ion order of their reducing strength?

A. Zinc and copper (I) nitrate solution.

[✓ B.] Chromium and zinc nitrate solution.

C. Copper and cadmium nitrate solution.

D. Cadmium and chromium nitrate solution.

Question 22 (1 mark)

Inspired from VCAA Chemistry Exam 2008
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2008/chem2-w.pdf#page=9

The following reactions occur spontaneously as written.

$2Cr^{2+}(aq) + Co^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + Co(s)$

$Co(s) + Pb^{2+}(aq) \rightarrow Co^{2+}(aq) + Pb(s)$

$Pb(s) + 2Cr^{3+}(aq) \rightarrow Pb^{2+}(aq) + 2Cr^{2+}(aq)$

Using this information, predict which one of the following pairs of reactants will react spontaneously.

A. $Co(s) + Fe^{3+}(aq)$

B. $Cr^{3+}(aq) + Fe^{2+}(aq)$

[✓ C.] $Cr^{2+}(aq) + Pb^{2+}(aq)$

D. $Pb(s) + Co^{2+}(aq)$

Pb^{2+}	Pb
Co^{2+}	Co
Cr^{3+}	Cr^{2+}
Fe^{3+}	Fe

Question 23 (1 mark)

The following reactions occur spontaneously.

$Co(s) + Hg^{2+}(aq) \rightarrow Co^{2+}(aq) + Hg(l)$

$Hg(l) + 2Ce^{4+}(aq) \rightarrow Hg^{2+}(aq) + 2Ce^{3+}(aq)$

$2Cr^{2+}(aq) + Co^{2+}(aq) \rightarrow Co(s) + 2Cr^{3+}(aq)$

Using this information, predict which one of the following pairs of reactants will react spontaneously.

A. Co(s) and $Ce^{3+}(aq)$.

B. $Cr^{3+}(aq)$ and Hg(l).

C. $Co^{2+}(aq)$ and $Ce^{4+}(aq)$.

[✓ D.] $Hg^{2+}(aq)$ and $Cr^{2+}(aq)$.

Ce^{4+}	Ce^{3+}
Hg^{2+}	Hg
Co^{2+}	Co
Cr^{3+}	Cr^{2+}

Space for Personal Notes

Question 24 (1 mark)

Inspired from VCAA Chemistry Exam 2020
https://www.vcaa.vic.edu.au/Documents/exams/chemistry/2020/2020chem-w.pdf#page=13

Consider the following half-equation.

$ClO_2(g) + e^- \rightleftharpoons ClO_2^-(aq)$

oxidant H^+ I^-

It is also known that:

- $ClO_2(g)$ will oxidise HI(aq), but not HCl(aq).
- $Fe^{3+}(aq)$ will oxidise HI(aq), but not $NaClO_2(aq)$.

Na^+ ClO_2^-

Based on this information, which of the following can act as an oxidising agent for Fe^{2+}?

A. $Cl_2(g)$ and $I_2(aq)$.

B. $Cl_2(g)$, but not $ClO_2(g)$.

[✓ C.] $ClO_2(g)$ and $Cl_2(g)$, but not $I_2(aq)$.

D. $Cl_2(g)$, $ClO_2(g)$ and $I_2(aq)$.

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Use the following information to answer the questions below.

Various reagents were mixed in separate flasks as shown in the table below.

Flask 1	Flask 2	Flask 3	Flask 4
$Cu(NO_3)_2(aq)$ + Sn	$Ag^+(aq)$ + Cd	Fe^{3+} (aq) + NaCl (aq)	I_2 solution + Cu

Question 25 (1 mark)

A reaction is likely to occur in:

[✓ A.] Flasks 1 and 2 but not in flask 3.

B. Flasks 1 and 3 but not in flask 2.

C. Flask 2 but not in flasks 1 and 3.

D. Flask 3 but not in flasks 1 and 2.

Question 26 (1 mark)

Using the electrochemical series, a reaction is predicted to occur in flask 4. However, no reaction had occurred by the time any reactions took place in the other flasks. Which one of the following is the most likely reason to explain this?

A. The iodine was in a different state to that shown in the electrochemical series.

B. The enthalpy change for the reaction has a positive value.

C. An alloy of copper and zinc was used mistakenly in place of the pure copper metal.

[✓ D.] The products are formed much more slowly than products in the other reactions.

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Section H: VCAA-Level Questions II (10 Marks)

INSTRUCTION: 10 Marks. 30 Seconds Reading. 9 Minutes Writing.

Question 27 (10 marks)

Gaseous hydrogen peroxide is bubbled into aqueous chloride ions, all at SLC.

a. A reaction is begins to occur.

i. Write the balanced half-equation for the reduction reaction. (1 mark)

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

ii. Write the overall reaction that takes place. (2 marks)

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

iii. Describe one observation expected as this reaction continues. (1 mark)

Bubbling due to oxygen gas forming.
Heat being released due to the redox reaction being exothermic.

iv. After being left undisturbed for a long time, 40.0 L of gaseous products are collected at SLC. Calculate the mass of hydrogen peroxide which must have reacted. (2 marks)

$$n(O_2) = \frac{V}{V_m} = \frac{40.0}{24.8} = 1.61\ mol$$

$$n(H_2O_2) = 2 \times n(O_2) = 2(1.61) = 3.23\ mol$$

$$m(H_2O_2) = n \times Mr = 3.23 \times (2 + 32) = 54.8\ g$$

v. Even after 20 minutes of the system being set up, there is no observable indication of the reaction described in **part i-iii.** occurring. Explain this phenomenon. (1 mark)

The reaction is occurring but extremely slowly and thus the observations are negligible.
This is because the electrochemical series does not dictate the rate of the reaction.

b. When manganese dioxide, MnO_2, is added to the hydrogen peroxide, the reaction occurs more rapidly. If the products are filtered at the end of the reaction, the MnO_2 can be recovered and reused.

Explain the role of the MnO_2. (1 mark)

It is a catalyst to speed up the rate of reaction.

Hydrogen peroxide can also react with concentrated nitric acid according to the following equation:

$$2NO_3^-(aq) + H_2O_2(aq) + 2H^+(aq) \rightarrow 2NO_2(g) + O_2(g) + 2H_2O(g)$$

c. Identify whether the nitric acid acts as the oxidant or the reductan. Justify your answer with reference to oxidation numbesr. (2 marks)

Oxidant with a decrease in oxidation number of from +5 to +4.
In H_2O_2 the oxidation number of oxygen is −1. In O_2 the oxidation number of oxygen is 0, an increase of 1. Increase in oxidation number is an oxidation process, hence H_2O_2 is the reductant. The oxidation number of nitrogen decreases from +5 to +4, with acidified NO_3^- being the oxidant.

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Section I: Extension Questions (9 Marks)

Question 28 (4 marks)

A sample of four unlabelled metals and 1 M solutions of the nitrate of the metals. The metals are labelled A, B, C, D and the solutions are labelled A^{2+}, B^{2+}, C^{2+}, D^{2+}.

An experiment was carried out and the following observations were made:

A^{2+}/A
D^{2+}/D
B^{2+}/B
C^{2+}/C

- Metal A remains unchanged in all solutions.
- Metal B becomes coated with another metal when placed in solutions of D^{2+} and A^{2+} only.
- Metal C becomes coated with another metal when placed in solutions of A^{2+}, B^{2+} and D^{2+}.

a. Consider the ranking obtained above.

i. State the strongest oxidant and the strongest reductant. (1 mark)

Strongest oxidant = $A^{2+}(aq)$
Strongest reductant = C(s)

ii. Write the overall reaction between the species identified in **part a.i.** (1 mark)

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

b. Would a reaction occur between B^{2+} and D(s)? Justify your answer. (2 marks)

No, a reaction will not occur as D is a weak reductant and B^{2+} is a weak oxidant.

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Question 29 (5 marks)

Rochelle mixes a solution of $Zn^{2+}(aq)$, $Co^{2+}(aq)$, $Fe^{2+}(aq)$ and $Sn^{2+}(aq)$ into a beaker of pure deionised water.

Rochelle then adds a stick of pure calcium into the mixture.

a. Identify the oxidation reaction in this situation. (1 mark)

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

b. Identify the reduction reaction in this situation. (1 mark)

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

c. After some time, a new reduction equation starts in the beaker. Identify the new reduction equation that would occur. (1 mark)

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

d. Are these reactions exothermic or endothermic? Identify the difference between the two. (2 marks)

Exothermic.
Exothermic reactions release energy into the environment and are usually from spontaneous reactions, whereas endothermic reactions absorb energy and are usually from non-spontaneous reactions.

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