Chemistry 40S Exam Review

Sample Extended Answer Questions
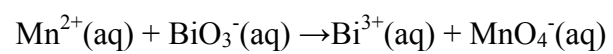
I: Aqueous Solutions

1. Consider the reaction that takes place between 0.10 mol/L aqueous solutions of iron (III) chloride, $FeCl_3$, and sodium phosphate, Na_3PO_4 at 25°C.
   Write the net ionic equation for the reaction. Include all state symbols for full marks.

2. 10.00 mL of an unknown concentration of sulfuric acid is neutralized with 23.50 mL of a 0.765 mol/L solution of sodium hydroxide.

   a) Write a balanced chemical equation for the reaction. Include all state symbols for full marks.

   b) Determine the concentration of the sulfuric acid solution.

3. Balance the following reaction in acidic solution using half reaction methods.

$$Mn^{2+}(aq) + BiO_3^-(aq) \rightarrow Bi^{3+}(aq) + MnO_4^-(aq)$$

Write your final balanced equation on the line below:

II: Atomic Structure

1. Consider element 18, Argon.

    a) State the full electron configuration for argon.

    b) Give the formulas of **two oppositely charged** ions which have the same electron configuration as argon.

2. State and explain the **differences** between:

    a) The atomic radius of nitrogen and oxygen.

    b) The electronegativity of fluorine and chlorine.

III: Kinetics

1. The reaction between **solid** ammonium chloride and aqueous sodium nitrite can be represented by the following equation:

$$NH_4Cl(s) + NaNO_2(aq) \rightarrow N_2(g) + 2H_2O(l) + NaCl(aq)$$
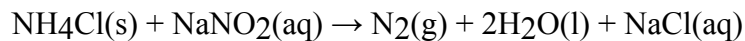
State and explain how the rate of formation of nitrogen would change if the same amount of ammonium chloride were used as large lumps instead of as a fine powder.

2. The graph below shows the volume of carbon dioxide gas produced against time when excess calcium carbonate is added to a fixed amount of 2.0 mol/L hydrochloric acid.
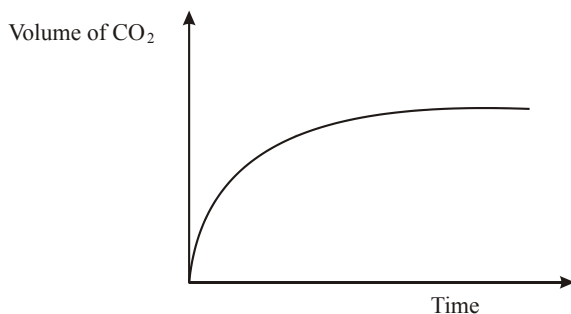
a) State and explain the change in the rate of reaction with respect to time.

Change:

Explanation:

b) On the graph, show how you should find the rate of the reaction at a particular instant. Include a rate equation for full marks.
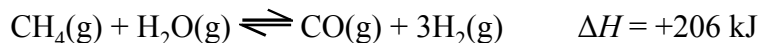
IV: Equilibrium

1. a) A 1.00 L flask is filled with 1.000 mol of H_2 and 2.000 mol of I_2 at 448°C and allowed to reach equilibrium. Analysis of the equilibrium mixture shows that the concentration of HI is 1.87×10^{-3} mol/L. Calculate Kc at this temperature for this reaction.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$
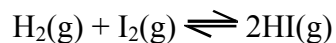
b) Is the reaction forward or reverse favored? Explain

2. An industrial gas mixture is produced by the catalytic reforming of methane using steam.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta H = +206 \text{ kJ}$$

Describe a change that would shift the position of equilibrium to the right and explain why the change shifts the equilibrium to the right.

3. The solubility product of LaF_3 is 2.0 x 10^{-19}. Calculate the molar solubility of LaF_3 in grams per liter.

V: Acids and Bases

1. Consider nitric acid and carbonic acid for this question.
   a) Identify which is the strong acid and which is the weak acid.

   Strong Acid:

   Weak Acid:

   b) Using conductivity measurements state and explain what you would expect to find if you were to test equimolar solutions of the two acids in the lab.
   Findings:

   Explanation:

   c) Write a dissociation equation for one of the two acids. Include state symbols for full marks.

2. a) Calculate the pH of acetic acid (Ka = 1.8×10^{-5}), $HC_2H_3O_2$ molecules ionized in a 0.05 mol/L solution.

b) Find the percent (%) dissociation.

VI: Electrochemistry

1. The standard electrode potentials for three electrode systems are given below.

$$Li^+(aq) + e^- \rightarrow Li(s) \qquad\qquad E^\ominus = -3.00V$$
$$Cr^{3+}(aq) + e^- \rightarrow Cr^{2+}(aq) \qquad\qquad E^\ominus = -0.41\ V$$
$$Cu^{2+}(aq) + e^- \rightarrow Cu^+(aq) \qquad\qquad E^\ominus = +0.34\ V$$

a) Using the data above, determine which species is the **best** oxidizing agent, and explain your reasoning.

b) Write an equation, including state symbols, for the overall reaction with the **greatest** cell potential and calculate the cell potential.

2. This question concerns the electrolysis of molten copper (II) chloride.

   a) Sketch a diagram of the electrolytic cell and label the anode and cathode. Be sure to include all other items (electron flow/movement of ions and cations) necessary to make the cell function properly.

   b) Write a balanced half equation for the reactions that occur at the anode and cathode. Be sure to include state symbols for full marks.

   c) Explain what would be observed on the surface of the cathode.

Sample Multiple Choice Questions

I: Aqueous Solution Chemistry

1. What is observed when equal volumes of 1.0 M $Ba(OH)_2$ and 1.0 M Na_2SO_4 are mixed?

   A) $BaSO_4$ precipitates.
   B) No precipitate forms.
   C) NaOH precipitates.
   D) Both NaOH and $BaSO_4$ precipitate.

2. Which of the following aqueous solutions, when combined with aqueous silver nitrate, $AgNO_3$, would form a precipitate?

   I. KI
   II. Na_2SO_4
   III. NH_4CH_3COO

   A) I only
   B) II only
   C) I and III only
   D) I, II and III

3. What is the net ionic equation for the reaction between $HNO_3((aq)$ and $KOH((aq))$?

   A) $K^+(aq) + NO_3^-(aq) \rightarrow KNO_3(s)$
   B) $HNO_3(aq) + KOH(aq) \rightarrow KNO_3(aq) + H_2O(l)$
   C) $K^+(aq) + H^-(aq) \rightarrow KH(s)$
   D) $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

4. What is/are the product(s) of a neutralization reaction between a strong acid and a strong base?

   I. Salt
   II. Water
   III. Carbon dioxide

   A) I only
   B) II only
   C) I and II only
   D) I, II and III

5. What volume of 0.50 mol/L barium hydroxide is required to completely neutralize 25 mL of 1.5 mol/L nitric acid?

   A) 75 mL
   B) 37.5 mL
   C) 30.0 mL
   D) 60.0 mL

6. In Ammonium phosphate, $(NH_4)_3PO_4$, what is the oxidation number of nitrogen?

   A) -3
   B) -9
   C) +2
   D) +3

7. In which reaction does chromium undergo a change in oxidation number?

   A) $Cr_2O_3 + 3H_2SO_4 \rightarrow Cr_2(SO_4)_3 + 3H_2O$
   B) $Cr_2(SO_4)_3 + 6NaOH \rightarrow 2Cr(OH)_3 + 3Na_2SO_4$
   C) $K_2Cr_2O7 + 4H_2SO_4 + 6HCl \rightarrow Cr_2(SO_4)_3 + K_2SO_4 + 7H_2O + 3Cl_2$
   D) $2K_2CrO_4 + H_2SO_4 \rightarrow K_2Cr_2O7 + K_2SO_4 + H_2O$

8. Consider the following reaction.

$$H_2SO_3(aq) + Sn^{4+}(aq) + H_2O(l) \rightarrow Sn^{2+}(aq) + HSO_4^-(aq) + 3H^+(aq)$$
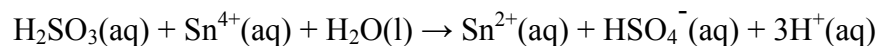
   Which statement is **correct**?

   A) H_2SO_3 is the reducing agent because it undergoes reduction.
   B) H_2SO_3 is the reducing agent because it undergoes oxidation.
   C) Sn^{4+} is the oxidizing agent because it undergoes oxidation.
   D) Sn^{4+} is the reducing agent because it undergoes oxidation.

9. When the oxidation reduction reaction below is balanced, what is the coefficient on Ag(s)?

$$Ag(s) + NO_3^-(aq) + H^+(aq) \rightarrow Ag^+(aq) + NO(g) + H_2O(l)$$
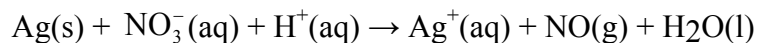
   A) 1
   B) 2
   C) 3
   D) 4

II: Atomic Structure

10. Which of the following types of electromagnetic radiation would have the **longest** wavelength?

    A) Infrared radiation
    B) X Ray
    C) Visible light
    D) Gamma Ray

11. What is the electron configuration for nickel?

    A) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$

    B) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$

    C) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^2 4p^6$

    D) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4p^2$

12. What atom has the electron configuration $[Ne]3s^2 3p^5$?

    A) S
    B) Se
    C) O
    D) Cl

13. For which element are the group number and the period the **same**?

    A) Li
    B) Be
    C) B
    D) Mg

14. When the following species are arranged in order of **decreasing** radius, what is the **correct** order?

    A) K^+, Ar , Cl^-

    B) Cl^-, K^+, Ar

    C) Cl^-, Ar, K^+

    D) Ar, Cl^-, K^+

15. Which of the following properties of the alkali metals **increase** from Li to Cs?

      I. Atomic radius
     II. Ionization energy
    III. Electronegativity

A) I only
B) I and II only
C) I and III only
D) I, II and III

16. Which properties of period 3 elements **decreases** from sodium to argon?

      I. Atomic radius
   II. Ionization energy
    III. Electronegativity

A) I only
B) I and III only
C) II and III only
D) I, II and III

III: Kinetics

17. The rate of a chemical reaction can sometimes be determined by measuring the change in mass of the reaction flask and its contents with time. For which of the following reactions would this technique be **most** successful?

A) Zinc metal with aqueous copper (II) sulfate
B) Magnesium metal with dilute hydrochloric acid
C) Aqueous lead (II) nitrate with aqueous potassium iodide
D) Aqueous sodium hydroxide with aqueous iron (III) nitrate

18. In the following reaction, the rate at which O_2 appears is 6.0×10^{-5} mol/L/s at a particular instant. At what rate is O_3 disappearing at this same time?
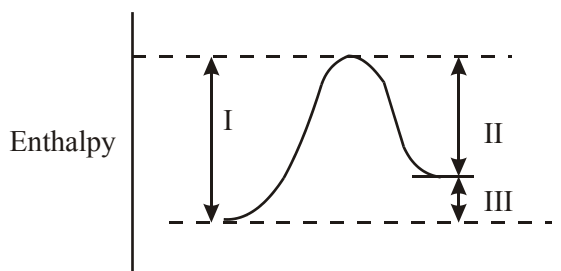
$$2O_3(g) \rightarrow 3O_2(g)$$
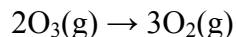
A) 4.0×10^{-5} mol/L/s
B) 9.0×10^{-5} mol/L/s
C) 3.6×10^{-4} mol/L/s
D) 1.0×10^{-5} mol/L/s

19. Which of the following is (are) important in determining whether a reaction occurs?

       I. Energy of the molecules
      II. Orientation of the molecules
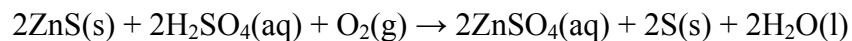
A) I only
B) II only
C) Both I and II
D) Neither I nor II

20. Which of the quantities in the enthalpy level diagram below is (are) affected by the use of a catalyst?

A) I only
B) III only
C) I and II only
D) II and III only

21. Consider the following reaction:

$$2ZnS(s) + 2H_2SO_4(aq) + O_2(g) \rightarrow 2ZnSO_4(aq) + 2S(s) + 2H_2O(l)$$

What changes would increase the reaction rate?

      I. Increasing the temperature
      II. Increasing $[H_2SO_4]$
      III. adding a suitable catalyst

A) I and II only
B) I and III only
C) II and III only
D) I, II, and III

22. In a multiple step reaction, which of the following best describes the **rate determining step**?

A) The step with the slowest moving particles
B) The step with the fewest reactant particles
C) The slowest step in a reaction
D) The last step in a reaction

IV: Equilibrium

23. A chemical reaction is at equilibrium. Compared to the rate of the of forward reaction, the rate of the reverse reaction is:

    A) faster and more product is produced
    B) faster and more reactant is produced
    C) the same and the reaction has stopped
    D) the same and the reaction continues in both directions

24. Consider the reaction between chlorine gas and aqueous hydroxide ions.

    $$Cl_2(g) + 2OH^-(aq) \rightleftharpoons OCl^-(aq) + Cl^-(aq) + H_2O(l)$$

    What is the **correct** Kc expression for the reaction?

    A) $\dfrac{[OCl^-][Cl^-]}{[Cl_2][[OH^-]^2}$

    B) $\dfrac{[Cl_2][OH^-]^2}{[OCl^-][Cl^-][H_2O]}$

    C) $\dfrac{[OCl^-][Cl^-][H_2O]}{[Cl_2][[2OH^-]}$

    D) $\dfrac{[OCl^-][Cl^-][H_2O]}{[Cl_2][[OH^-]^2}$

25. Which of the following Kc values would represent a reaction that favors products **most**?

    A) 1.02×10^{-3}
    B) 4.51×10^9
    C) 623
    D) 3.87×10^{-8}

26. A mixture of nitrogen and hydrogen in a reaction vessel is allowed to attain equilibrium at 500°C. The equilibrium mixture was analyzed and found to contain 7.38 mol/L H_2, 2.46 mol/L N_2 and 0.166 mol/L NH_3. From this data, calculate the equilibrium constant, Kc, for the reaction.

    $$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$
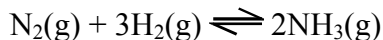
    A) 2.79×10^{-5}
    B) 3.59×10^4
    C) 9.14×10^{-3}
    D) 1.09×10^2

Use the following reaction for questions 27 and 28.

$$NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g) \qquad \Delta H = +176 \text{ kJ}$$

27. Which of the following would cause a shift to the right?

    A) Adding NH_4Cl
    B) Removing NH_3
   C) Increasing pressure
    D) Decreasing temperature

28. When HCl is added, how do the concentrations of NH_3 and HCl at the new equilibrium compare to the original equilibrium concentrations?

	$[NH_3]$	$[HCl]$
A)	Higher	Higher
B)	Higher	Lower
C)	Lower	Higher
D)	Lower	Lower

29. Given the following equation at equilibrium at 679°C,

$$A(g) + 2B(g) \rightleftharpoons 2C(g) + 2D(g) \qquad \Delta H = \text{-60 kJ}$$
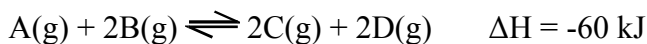
Use the graph of reaction to predict the stresses placed on the system at times T1 and T2.
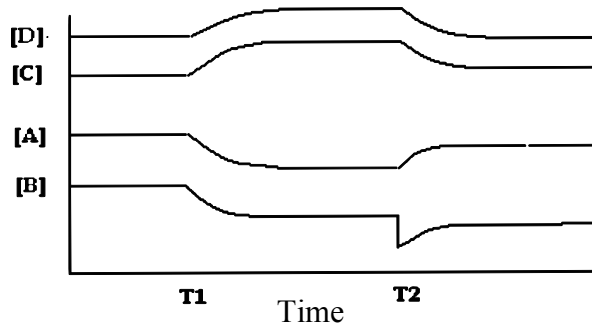

	Time 1 (T1)	Time 2 (T2)
A)	Increase in temperature	Removal of B
B)	Decrease in temperature	Removal of B
C)	Increase in temperature	Addition of A
D)	Decrease in temperature	Addition of A

30. Which of the following is the **correct** Ksp expression for a saturated solution of barium phosphate?

A) $\dfrac{[Ba^{2+}][PO_4^{3-}]}{BaPO_4}$

B) $[Ba^{2+}][PO_4^{3-}]$

C) $[Ba^{2+}]^3[PO_4^{3-}]^2$

D) $\dfrac{[Ba^{2+}]^3[PO_4^{3-}]^2}{BaPO_4}$

31. Given the precipitation reaction:

$$Na_2S(aq) + Fe(NO_3)_2\ (aq) \rightarrow FeS(s) + 2NaNO_3\ (aq)$$
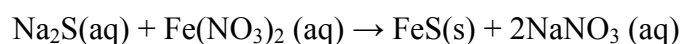
What is the Ksp expression for the saturated solution formed?

A) $Ksp = [Fe^{2+}][S^{2-}]$

B) $Ksp = \dfrac{[Fe^{2+}][S^{2-}]}{[FeS]}$

C) $Ksp = \dfrac{[FeS]}{[Fe^{2+}][S^{2-}]}$

D) $Ksp = \dfrac{1}{[Fe^{2+}][S^{2-}]}$

32. The Ksp value for $BaSO_4$ is 1.1×10^{-10}. What is the concentration of Barium ions, Ba^{2+}, in a saturated solution of barium sulfate?

A) 5.5×10^{-11} mol/L
B) 2.2×10^{-10} mol/L
C) 1.2×10^{-20} mol/L
D) 1.1×10^{-5} mol/L

V: Acids and Bases

33. Which of the following **best** describes the Lewis theory of bases?

A) All acid solutions split up to form a hydrogen ion and an anion.
B) An acid acts as a donor of hydrogen ions (proton donor).
C) A species that donates a pair of electrons to form a bond.
D) A species that accepts a pair of electrons to form a bond.

34. In the reaction $CO_3{}^{2-} + H_2O \rightleftharpoons HCO_3{}^- + OH^-$, the carbonate ion is acting as a(n) _____.

    A) Arrhenius base
    B) Arrhenius acid
    C) Brønsted-Lowry base
    D) Brønsted-Lowry acid

Use the following reaction for questions 35 and 36.

$$Energy + H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$$
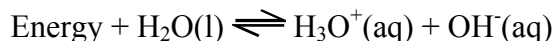
35. What does this equation **best** represent?

    A) Kw
    B) The ionization of water
    C) The acid base nature of water.
    D) The equilibrium constant of water

36. Which of the following scenarios is **correct** concerning the change in concentrations of the species and the type of species that would be present?

	As [OH⁻] ___.	[H₃O⁺] will ___.	Type of Solution
A)	Increases	Decrease	Acidic
B)	Increases	Decrease	Basic
C)	Decreases	Decrease	Acidic
D)	Increases	Increase	Basic

37. A chemical indicator typically

    A) changes colour when acid or base is added.
    B) resists changes in pH when acid or base is added.
    C) resists changes in colour when acid or base is added.
    D) neutralizes acids and indicates this with a colour change.

38. What is the pH of 0.50M LiOH?

    A) 2.0×10^{-14}
    B) -0.30
    C) 0.30
    D) 13.7

39. Which of the following 0.10M solutions would have the **lowest** pH?

   A) HF
   B) NH_3
   C) HNO_3
   D) H_2CO_3

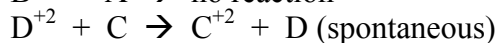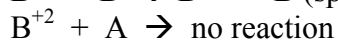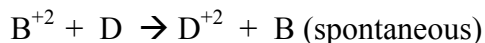40. What is the **correct** Ka expression for the ionization of benzoic acid in water?

   A) $\dfrac{[C_6H_5COOH][H_2O]}{[C_6H_5COO^-][H_3O^+]}$

   B) $\dfrac{[C_6H_5COOH]}{[C_6H_5COO^-][H_3O^+]}$

   C) $\dfrac{[C_6H_5COO^-][H_3O^+]}{[C_6H_5COOH]}$

   D) $\dfrac{[C_6H_5COO^-][H_3O^+]}{[C_6H_5COOH][H_2O]}$

41. A 0.020 mol/L solution of niacin has a pH of 3.26. Calculate the percent ionization of niacin.
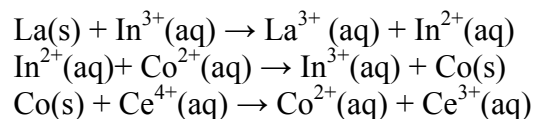
   A) 2.75%
   B) 0.613 %
   C) 36.4%
   D) 1.63%

VI: **Electrochemistry**

42. Use the data below to arrange the elements A, B, C and D in decreasing order of ability as oxidizer agents.

$$B^{+2} + D \rightarrow D^{+2} + B \text{ (spontaneous)}$$
$$B^{+2} + A \rightarrow \text{ no reaction}$$
$$D^{+2} + C \rightarrow C^{+2} + D \text{ (spontaneous)}$$

   A) D, B, A, C
   B) A, B, D, C
   C) C, D, B, A
   D) B, D, A, C

43. The following reactions are spontaneous as written.

$$La(s) + In^{3+}(aq) \rightarrow La^{3+}(aq) + In^{2+}(aq)$$
$$In^{2+}(aq) + Co^{2+}(aq) \rightarrow In^{3+}(aq) + Co(s)$$
$$Co(s) + Ce^{4+}(aq) \rightarrow Co^{2+}(aq) + Ce^{3+}(aq)$$

Which of the following pairs will react spontaneously?

I. $Co(s) + La^{3+}(aq)$
II. $Ce^{4+}(aq) + In^{2+}(aq)$
III. $La(s) + Ce^{4+}(aq)$

A) I only
B) II only
C) III only
D) II and III only

44. For the reaction below in a voltaic cell, identify the species that would receive electrons along with the location to where the electrons are gained.

$$Au^{3+}(aq) + Zn(s) \rightleftharpoons Au(s) + Zn^{2+}(aq)$$
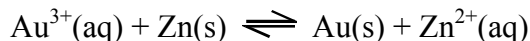
| Substance recieving electrons	Location
A) $Zn(s)$	Cathode
B) $Au^{3+}(aq)$	Cathode
C) $Zn(s)$	Anode
D) $Au^{3+}(aq)$	Anode

45. A voltaic cell consists of an Ag electrode in a 1.0 mol/L solution of AgNO$_3$ and a Ni electrode in a 1.0 mol/L solution of Ni(NO$_3$)$_2$. What is the **correct** overall reaction for the cell?

A) $2Ag^{+}(aq) + Ni(s) \rightarrow 2Ag(s) + Ni^{2+}(aq)$
B) $2Ag(s) + Ni^{2+}(aq) \rightarrow 2Ag^{+}(aq) + Ni(s)$
C) $2Ag^{+}(aq) + 2Ag(s) \rightarrow Ni(s) + Ni^{2+}(aq)$
D) $Ni(s) + Ni^{2+}(aq) \rightarrow 2Ag^{+}(aq) + 2Ag(s)$

46. What is the metal that is used for the standard hydrogen electrode?

A) Copper
B) Silver
C) Gold
D) Platinum

47. Calculate the electrochemical potential of the following cell:

$$Mg(s) \mid Mg^{2+} \| Cu^{2+} \mid Cu(s)$$
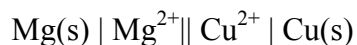
A) +2.52 V
B) +2.71 V
C) +2.89 V
D) +2.03 V

48. Which of the following would react spontaneously with Sn(s) to produce $Sn^{2+}(aq)$?

    I. $Pb^{2+}(aq)$
    II. $Mg^{2+}(aq)$
    III. MnO_4^- (acidified)

A) I only
B) II only
C) I and III only
D) I, II and III

49. Select the **correct** description of a voltaic cell.

	Produces or uses electricity?	Spontaneous reaction or non – spontaneous?
A)	Uses	Non – spontaneous
B)	Uses	Spontaneous
C)	Produces	Non – spontaneous
D)	Produces	Spontaneous

50. What occurs during the electrolysis of a molten salt?

A) Electricity is produced by a spontaneous redox reaction.
B) Electricity is used to cause a non-spontaneous redox reaction to occur.
C) Electrons flow through the molten salt.
D) Electrons are removed from both ions of the molten salt.