# SCH4U: EXAM · REVIEW

1. The total number of orbitals containing electrons in the vanadium atom is
    A. 4   B. 7   C. 12   D. 13

2. Which one of the following covalent bonds is the most polar?
    A. H– O   B. H– N   C. H– Cl   D. H– F

3. Which of the molecule is a polar molecule?
    A. NF_3 B. Cl_2 C. CCl_4 D. CO_2

4. Consider the following potential energy diagram that represents two different reaction
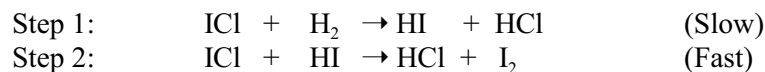

    Progress of the reaction
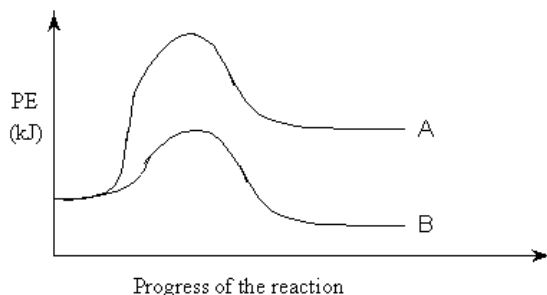
    Which of the following statements is correct?

    A. Reactions A and B are both exothermic.
    B. Reactions A and B are both endothermic.
    C. Reactions A is exothermic and reaction B is endothermic.
    D. Reactions A is endothermic and reaction B is exothermic.

5. Consider the following potential energy diagram.

    Progress of the reaction
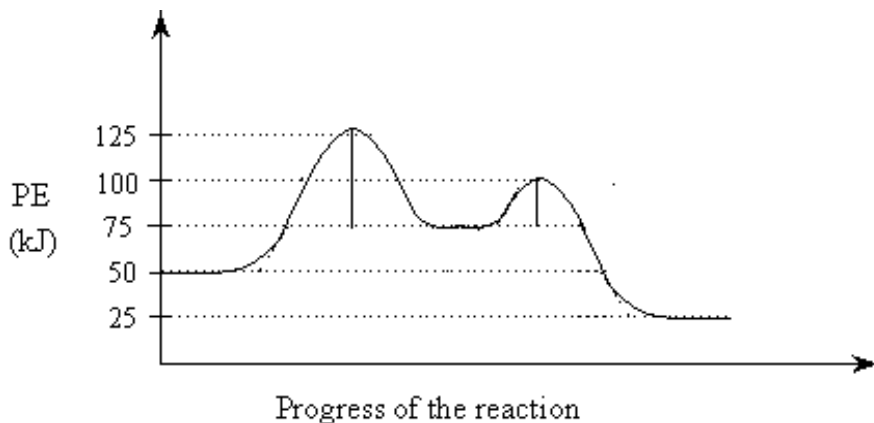
    The activation energy for the **forward** reaction is:

    A. 25 kJ   B. 50 kJ   C. 75 kJ   D. 125 kJ

6. Consider the following reaction mechanism:

Step 1:	$ICl + H_2 \rightarrow HI + HCl$	(Slow)
Step 2:	$ICl + HI \rightarrow HCl + I_2$	(Fast)

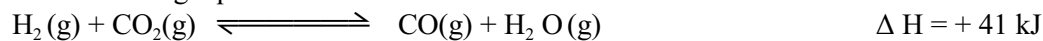   The species HCl is a:
    A. Product   B. Catalyst   C. Reactant   D. Reaction intermediate

7. In which of the following does the entropy decrease ?

    A. $NaCl(s) \rightarrow Na^+(aq) + Cl^-(aq)$
    B. $4\,NO(g) + 6\,H_2O(g) \rightarrow 4\,NH_3(g) + 5\,O_2(g)$
    C. $2\,NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$
    D. $CaCO_3(g) + 2\,HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$

8. Consider the following equilibrium

$$H_2(g) + CO_2(g) \rightleftharpoons CO(g) + H_2O(g) \qquad\qquad \Delta H = +41\ kJ$$

The temperature of the above equilibrium system is increased while kept at a constant volume. A new state of equilibrium is established in which there is

    A.   An increase in [CO] and a decrease in K_{eq}
    B.   An increase in [CO] and a increase in K_{eq}
    C.   An increase in $[CO_2]$ and a decrease in K_{eq}
    D.   An increase in $[CO_2]$ and a increase in K_{eq}

9. Consider the following equilibrium.
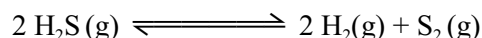
$$2\,SO_3(g) \rightleftharpoons 2\,SO_2(g) + O_2(g)$$
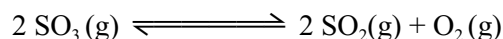
The volume of the system is decreased at a constant temperature. A new state of equilibrium is established by a shift of the original equilibrium to the

    A.   Left and $[SO_3]$ increases.
    B.   Right and $[SO_3]$ decreases.
    C.   Left and $[SO_3]$ remains unchanged.
    D.   Right and $[SO_3]$ remains unchanged.

10. Consider the following equilibrium:

$$2\,H_2S(g) \rightleftharpoons 2\,H_2(g) + S_2(g)$$

At equilibrium, $[H_2S] = 0.50$ mol/L, $[H_2] = 0.10$ mol/L and $[S_2] = 0.40$ mol/L. The value of K_{eq} is calculated using the ratio

    A. $\dfrac{(0.10)(0.40)}{(0.50)}$

    B. $\dfrac{(0.10)^2(0.40)}{(0.50)^2}$

    C. $\dfrac{(0.50)}{(0.10)(0.40)}$

    D. $\dfrac{(0.50)^2}{(0.10)^2(0.40)}$

11. Consider the following equilibrium

$$I_2 \text{ (s)} + H_2O\text{(l)} \rightleftharpoons H^+\text{(aq)} + I^-\text{(aq)} + HOI\text{(aq)}$$

The equilibrium constant expression for the above system is

A. $K_{eq} = [H^+][I^-]$

B. $K_{eq} = [H^+][I^-][HOI]$

C. $K_{eq} = \dfrac{[H^+][I^-][HOI]}{[I_2][H_2O]}$

D. $K_{eq} = \dfrac{[H^+][I^-][HOI]}{[H_2O]}$

12. In an exothermic equilibrium reaction involving only gases, the value of K_{eq} can be **decreased** by

A. adding some reactant gas.
B. Removing some reactant gas.
C. increasing the temperature.
D. decreasing the temperature.

13. Consider the following equilibrium:

$$2\,NO\text{ (g)} + Cl_2\text{(g)} \rightleftharpoons 2\,NOCl\text{(g)} \qquad K_{eq} = 12$$
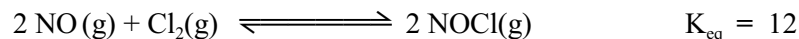
At equilibrium, [NOCl] = 1.60 mol/L and [NO] = 0.80 mol/L. The [Cl₂] is

A. 0.17 mol/L
B. 0.27 mol/L
C. 0.33 mol/L
D. 3.0 mol/L

14. The equation represents the equilibrium in a saturated solution of $Fe_2(SO_4)_3$ is

A. $Fe_2(SO_4)_3 \text{ (s)} \rightleftharpoons 3\,Fe^{2+}\text{(aq)} + 2\,SO_4^{3-}\text{(aq)}$
B. $Fe_2(SO_4)_3 \text{ (s)} \rightleftharpoons 2\,Fe^{2+}\text{(aq)} + 3\,SO_4^{3-}\text{(aq)}$
C. $Fe_2(SO_4)_3 \text{ (s)} \rightleftharpoons 3\,Fe^{3+}\text{(aq)} + 2\,SO_4^{2-}\text{(aq)}$
D. $Fe_2(SO_4)_3 \text{ (s)} \rightleftharpoons 2\,Fe^{3+}\text{(aq)} + 3\,SO_4^{2-}\text{(aq)}$

15. A solution of $AgNO_3$ is slowly added to a mixture containing 0.10 M I^-, Cl^-, Br^- and IO_3^-. The precipitate which forms first is

A. AgI   B. AgCl   C. AgBr   D. $AgIO_3$

16. Which of the following ions could be used to separate Cl^-(aq) from SO_4^{2-}(aq) by precipitation?
A. Ag^+ B. Ca^{2+} C. NH_4^+ D. Pb^{2+}

3

17. Which of the following could be used to precipitate both Mg^{2+} and Ca^{2+} from hard water?

    A. Lithium sulphate
    B. Sodium phosphate
    C. Potassium sulphide
    D. Ammonium chloride
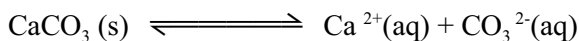
18. The solubility of manganese (II) sulphide is 1.7×10^{-7} M at $25^{\circ}C$. The solubility product constant is:
    A. 2.9×10^{-14}
    B. 1.7×10^{-7}
    C. 3.4×10^{-7}
    D. 4.1×10^{-4}

19. What is the maximum $[Ag^{+}]$ that can exist in 0.20 M $NaBrO_{3 \ (aq)}$?

    A. 1.1×10^{-5} M
    B. 5.3×10^{-5} M
    C. 2.6×10^{-4} M
    D. 7.3×10^{-3} M

20. Consider the following equilibrium:

    $$CaCO_3 \ (s) \ \rightleftharpoons \ Ca^{2+}(aq) + CO_3^{2-}(aq)$$

    Which of the following reagents, when added to the equilibrium system, would cause more $CaCO_3$ to dissolve?

    A. $KNO_3 \ (s)$
    B. $CaCO_3 \ (s)$
    C. $H_2C_2O_4 \ (s)$
    D. $Na_2CO_3 \ (s)$

21. The conjugate base of $H_2BO_3^{\ -}$ is :

    A. $BO_3^{\ 3-}$
    B. H_3BO_3
    C. $HBO_3^{\ 2-}$
    D. $H_3BO_3^{\ -}$

22. Which of the following is the **weakest** acid ?

    A. $HClO$
    B. $HClO_2$
    C. $HClO_3$
    D. $HClO_4$

23. Consider the following equilibrium for the indicator bromthymol blue:

$$HInd \rightleftharpoons H^+ + Ind^-$$
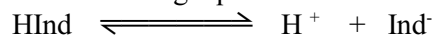
A solution of bromthymol blue is yellow. What should a student do to change the colour of the solution to blue?

A. Add a base to shift the equilibrium left.
B. Add an acid to shift the equilibrium left.
C. Add a base to shift the equilibrium right.
D. Add an acid to shift the equilibrium right.

24. Which of the following is amphiprotic in water?

A. SO_2
B. SO_3^{2-}
C. HSO_3^-
D. H_2SO_3

25. Water acts as a base when it reacts with

A. CN^-
B. NH_3
C. NO_2^-
D. NH_4^+

26. The $[OH^-]$ in 0.050 M HNO_3 at 25°C is

A. 5.0×10^{-16} M
B. 1.0×10^{-14} M
C. 2.0×10^{-13} M
D. 5.0×10^{-2} M

27. Consider the following equilibrium constant expression:

$$K = \frac{[H_2S][OH^-]}{[HS^-]}$$

A. K_b for H_2S
B. K_a for H_2S
C. K_b for HS^-
D. K_a for HS^-

28. Which of the following 0.10 M solutions will be yellow in the presence of the indicator chlorophenol red?

A. $AlCl_3$
B. $CaCl_2$
C. K_2CO_3
D. Na_3PO_4

5

29. Consider the following data:

Solution	Initial pH	Final pH
1	1.0	4.0
2	2.0	6.0
3	6.0	3.0
4	9.0	3.0

In which solution has the $[H_3O^+]$ increased 1000 times?

A. 1
B. 2
C. 3
D. 4

30. The pOH of an aqueous solution is equal to

A. $14 + pH$

B. $pK_w - pH$

C. $- \log pK_w$

D. $- \log [H_3O^+]$

31. The reaction of a strong acid with a strong base produces:

A. A salt and water.

B. A base and an acid.

C. A metallic oxide and water.

D. A non-metallic oxide and water.

32. The stoichiometric point of a titration is reached when 35.50 mL 0.40 M HBr is added to a 25.00 mL sample of LiOH. The original [LiOH] is

A. 0.014 M
B. 0.024 M
C. 0.28 M
D. 0.57 M

33. What is the pH of a solution prepared by adding 0.50 mol KOH to 1.0 L of 0.30 M HNO_3?

A. 0.20
B. 0.70
C. 13.30
D. 13.80

34. A **basic** buffer solution can be prepared by mixing equal numbers of moles of

    A. NH_4Cl and HCl
    B. $NaCl$ and $NaOH$
    C. Na_2CO_3 and $NaHCO_3$
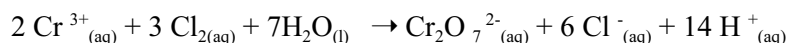   D. $NaCH_3COO$ and CH_3COOH

35. The pH range of 'acid rain' is often
    A.   3 to 6
    B.   6 to 8
    C.   7 to 9
    D.   10 to 12

36. Identify the indicator that is blue in a solution when $[H_3O^+] = 2.5 \times 10^{-6}$. (See Textbook for indicators)

    A.   Thymol blue
    B.   Thymolphthalein
    C.   Bromothymol blue
    D.   Bromocresol green

37. Consider the following redox reaction:

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

The species which loses electrons is:

    A. Cl_2
    B. Cr^{3+}
    C. H_2O
    D. $Cr_2O_7^{2-}$

38. The species which gains electrons in a redox reaction:

    A.   Loses mass.
    B.   Is oxidized.
    C.   Is the oxidizing agent.
    D.   Increases in oxidation number.

39. The oxidation number of carbon in CaC_2O_4 is

    A.   +2
    B.   +3
    C.   +4
    D.   +6

40. When MnO_4^- reacts to form Mn^{2+}, the manganese in MnO_4^- is:

    A.   Reduced as its oxidation number increases.
    B.   Reduced as its oxidation number decreases.
    C.   Oxidized as its oxidation number increases.
    D.   Oxidized as its oxidation number decreases.

Use the following Cell Notation: $Ni_{(s)} | Ni^{+2}_{(aq)} (IM) \ || \ Ag^{+1}_{(aq)} (IM) | Ag_{(s)}$
to answer questions 41 to 43.
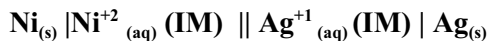
41. The balanced equation for the overall reaction is
    A. $Ni^+_{(aq)} + Ag_{(s)} \rightarrow Ag^+_{(aq)} + Ni_{(s)}$
    B. $Ni_{(s)} + Ag^+_{(aq)} \rightarrow Ag_{(s)} + Ni^+_{(aq)}$
    C. $Ni^{2+}_{(aq)} + 2 Ag_{(s)} \rightarrow 2 Ag^+_{(aq)} + Ni_{(s)}$
    D. $Ni_{(s)} + 2 Ag^+_{(aq)} \rightarrow 2 Ag_{(s)} + Ni^{2+}_{(aq)}$

42. This redox reaction occurs because:
    A. $Ag_{(s)}$ is a stronger oxidizing agent than $Ni_{(s)}$
    B. $Ag_{(s)}$ is a weaker reducing agent than $Ni_{(s)}$
    C. $Ag^+_{(aq)}$ is a stronger reducing agent than $Ni^{2+}_{(aq)}$
    D. $Ag^+_{(aq)}$ is a weaker oxidizing agent than $Ni^{2+}_{(aq)}$

43. The initial cell voltage at 25 ºC is:

    A. - 1.06 V   B. - 0.54 V   C. + 0.54 V   D. + 1.06 V

44. In the electrolysis of molten zinc chloride, the half-reaction at the anode is

    A. $Cl_2 + 2 e^- \rightarrow 2 Cl^-$
    B. $2 Cl^{-1} \rightarrow Cl_2 + 2 e^-$
    C. $Zn^{2+} + 2 e^- \rightarrow Zn$
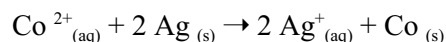   D. $Zn \rightarrow Zn^{2+} + 2 e^-$

45. Corrosion of iron can be prevented by attaching a piece of

    A. Mn   B. Cu   C. Pb   D. Sn

46. To plate a nickel coin with copper,

    A. The nickel coin must be the cathode.
    B. The cathode must be made of copper.
    C. The electrons must flow to the anode.
    D. The solution must contain nickel ions.

47. Consider the following redox reaction:

    $$Co^{2+}_{(aq)} + 2 Ag_{(s)} \rightarrow 2 Ag^+_{(aq)} + Co_{(s)}$$

    The reaction is:

    A. Spontaneous and Eº is positive.
    B. Spontaneous and Eº is negative.
    C. Non-spontaneous and Eº is positive
    D. Non-spontaneous and Eº is negative

48. Which of the following ions can be reduced from an aqueous solution ?

    A. Ba^{2+} B. Al^{3+} C. Sn^{2+} D. Na^+

This is the end of the multiple-choice section.
Answer the remaining questions in Section B, directly in the spaces provided.

OVER

PART B: WRITTEN-RESPONSE

> **INSTRUCTIONS:** You will be expected to communicate your knowledge and understanding of chemical principles in a clear and logical manners.
> – Your steps and assumptions leading to a solution must be written in the spaces below the questions.
> – Answers must include units where appropriate and be given to the correct number of significant figures.
> – **For questions involving calculation, full marks will NOT be given for providing only an answer.**

Value : 35 marks   **Suggested Time: 50 minutes**

1. a)   On the graph below, draw the potential energy diagram for an exothermic reaction and label the activation energy.   **(1 mark)**

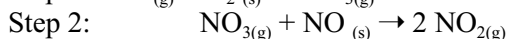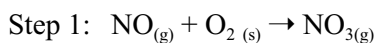   b)   Define the term *activation energy.*   **(1 mark)**

    _____

    _____

    _____

> Score for
> Question 1:
> 1.   _____
>   (2)

2.   Consider the following reaction mechanism:

Step 1: $NO_{(g)} + O_{2\ (s)} \rightarrow NO_{3(g)}$
Step 2: $NO_{3(g)} + NO_{\ (s)} \rightarrow 2\ NO_{2(g)}$

a)   Identify a reaction intermediate.   **(1 mark)**
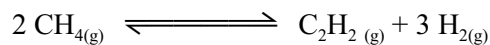
    _____

b)   Write the equation for the overall reaction.   **(1 mark)**

> Score for
> Question 2:
> 2.   _____
>   (2)

OVER

3.   Consider the following equilibrium:
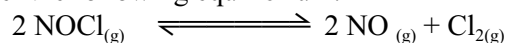
$$2 \, CH_{4(g)} \rightleftharpoons C_2H_{2 \, (g)} + 3 \, H_{2(g)}$$

A 0.180 mol sample of CH_4 is added to an empty 1.00 L container. At equilibrium, the $[C_2H_2]$ is 0.0800 mol/L. Calculate the equilibrium constant.   **(4 marks)**

Score for
Question 3:
3. _____
         (4)

4.   Consider the following equilibrium:
$$2 \, NOCl_{(g)} \rightleftharpoons 2 \, NO_{(g)} + Cl_{2(g)}$$

A chemist places 2.00 mol NOCl in a 1.0 L container. Describe the changes in [NOCl] and $[Cl_2]$ as the system approaches equilibrium. **(1 mark)**

_____

_____

_____

Score for
Question 4:
4. _____
         (1)

5.   A saturated solution of $BaSO_4$ is given to patients needing digestive tract x-rays.
a)   Write an equation that represents the solubility equilibrium.   **(1 mark)**

b)   Calculate the $[Ba^{2+}]$ present in the saturated solution.   **(2 marks)**
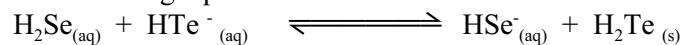
Score for
Question 5:
5. _____
         (3)

OVER

6.   Will a precipitate form when 90.0 mL of 1.00×10^{-2} M $Cu(NO_3)_2$ and 10.0 mL of 1.00×10^{-2} M $NaIO_3$ are mixed? Explain using appropriate calculations. **(3 marks)**

7.   Consider te following equilibrium:

$$H_2Se_{(aq)} + HTe^-_{(aq)} \rightleftharpoons HSe^-_{(aq)} + H_2Te_{(s)}$$

The reactants are favoured in this equilibrium.

a)   Identify the stronger acid. _____ **(1 mark)**

b)   Identify the weaker base. _____ **(1 mark)**

8.   The hydrogen carbonate ion can act as a weak base. Use calculations to determine the K_b of a solution containing 0.10 M hydrogen carbonate ion, if it has a pH 3.

               (3 marks)

9.   Calculate the pH of a 0.200 M solution of vitamin C, (ascorbic acid), a weak acid with a $K_a = 7.91 \times 10^{-1}$ at 25 ^{O}C .   **3 marks)**

11

ANSWER KEY

Multiple Choice Answers

1.	D	13.	C	25.	D	37.	B
2.	D	14.	D	26.	C	38.	C
3.	A	15.	A	27.	C	39.	B
4.	D	16.	B	28.	A	40.	B
5.	C	17.	B	29.	C	41.	D
6.	A	18.	A	30.	B	42.	B
7.	B	19.	C	31.	A	43.	D
8.	B	20.	C	32.	D	44.	B
9.	A	21.	C	33.	C	45.	A
10.	B	22.	A	34.	C	46.	A
11.	B	23.	C	35.	A	47.	D
12.	C	24.	C	36.	D	48.	C

PART B: Answers

2.   (a) NO_3 (b) $2\,NO + O_2 \rightarrow 2\,NO_2$

3.   2.76

5.   (a) $BaSO_4 \rightarrow Ba^{2+} + SO_4^{2-}$

        (b) 3.87×10^{-5} (See K_{sp} Table)

6.   No, since K_{sp} for $Cu(IO_3)_2 = 7.4 \times 10^{-8}$

7.   (a) H_2Se (b) HTe^-