

1. REACTION KINETICS

Introduction

A1. give examples of reactions proceeding at different rates

0106-MC1-A1

1. Which of the following reactions is slowest at room temperature?

(1 mark)

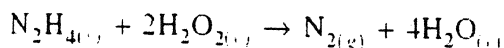
- A. $\text{NH}_3(g) + \text{HCl}(g) \rightarrow \text{NH}_4\text{Cl}(s)$
- B. $\text{MgCl}_2(s) + \text{Ca}(s) \rightarrow \text{Mg}(s) + \text{CaCl}_2(s)$
- C. $\text{HCl}(aq) + \text{NaOH}(aq) \rightarrow \text{NaCl}(aq) + \text{H}_2\text{O}(l)$
- D. $\text{Ba}(\text{NO}_3)_2(aq) + \text{Na}_2\text{SO}_4(aq) \rightarrow \text{BaSO}_4(s) + 2\text{NaNO}_3(aq)$

A2. describe rate in terms of some quantity (produced or consumed) per unit of time

0108-MC01-A2

1. Consider the following reaction:

(1 mark)



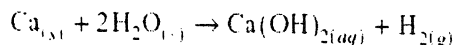
In 5.0 seconds, 0.015 mol of H_2O_2 is consumed. The rate of production of N_2 is

- A. 1.5×10^{-3} mol/s
- B. 3.0×10^{-3} mol/s
- C. 6.0×10^{-3} mol/s
- D. 1.5×10^{-2} mol/s

A3. experimentally determine rate of a reaction

9901-MC1-A3

1. Consider the reaction:



At a certain temperature, 2.50 g Ca reacts completely in 30.0 seconds.
The rate of consumption of Ca is

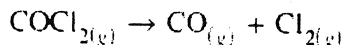
- A. 0.00208 mol/min
- B. 0.0833 mol/min
- C. 0.125 mol/min
- D. 5.00 mol/min

A4. identify properties that could be monitored in order to determine a reaction rate

0106-MC2-A4

2. Consider the following reaction:

(1 mark)



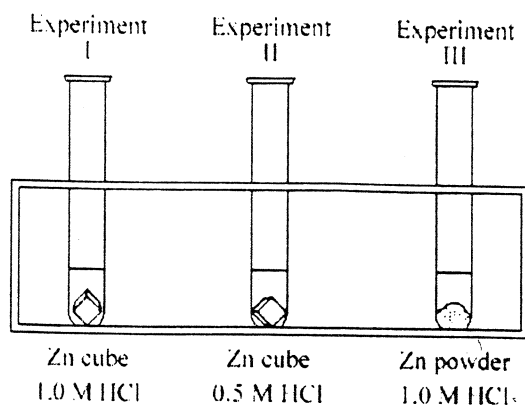
Which of the following could be used to determine reaction rate in a closed system?

- A. a decrease in gas pressure
- B. an increase in gas pressure
- C. a decrease in the mass of the system
- D. an increase in the mass of the system

A5. recognize some of the factors that control reaction rates

0006-MC4-A5

4. Consider the following experiments, each involving equal masses of zinc and 10.0 mL of acid:



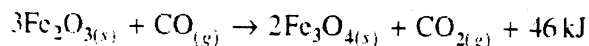
The rate of reaction in order from fastest to slowest is

- A. I > II > III
- B. II > I > III
- C. III > I > II
- D. III > II > I

A6. compare and contrast factors affecting the rates of both homogeneous and heterogeneous reactions
0108-MC2-A6

2. Consider the following reaction:

(1 mark)



Which of the following would cause the rate of the reaction to increase?

- A. removing the Fe_3O_4
- B. decreasing the temperature
- C. increasing the surface area of Fe_2O_3
- D. increasing the volume of the reaction vessel

A7. discuss situations in which the rate of reaction must be controlled

No Examples Found!

Collision Theory

B1. demonstrate an awareness of the following:

- reactions are the result of collisions between reactant particles
- not all collisions are successful
- sufficient kinetic energy (KE) and favourable geometry are required
- to increase the rate of a reaction one must increase the frequency of successful collisions
- energy changes are involved in reactions as bonds are broken and formed

0004-MC3-B1

3. Which of the following changes will increase the average kinetic energy of reactant molecules?

- A. adding a catalyst
- B. increasing the temperature
- C. increasing the surface area
- D. increasing the concentration

B2. describe the activated complex in terms of its potential energy (PE), stability, and structure
0008-MC4-B2

4. Which of the following is true for an activated complex?

- A. stable and has low PE
- B. stable and has high PE
- C. unstable and has low PE
- D. unstable and has high PE

B3. define *activation energy*

0108-MC3-B3

3. *Activation energy* is described as

(1 mark)

- A. the energy of the activated complex.
- B. a point on the PE diagram where $KE = PE$.
- C. the unstable high PE structural arrangement of atoms.
- D. the minimum PE difference between the activated complex and the reactants.

B4. describe the relationship between activation energy and rate of reaction

0104-MC5-B4

5. What is the relationship between the activation energy and the rate of a reaction?

(1 mark)

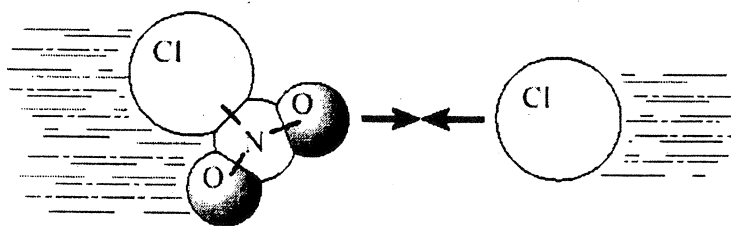
- A. When the activation energy is high, the rate of reaction is fast.
- B. When the activation energy is low, the rate of reaction is slow.
- C. When the activation energy is high, the rate of reaction is slow.
- D. There is no relationship between activation energy and rate of reaction.

B5. describe the changes in KE and PE as reactant molecules approach each other

0106-MC5-B5

5. The following diagram shows reactant molecules approaching one another:

(2 marks)



What is happening to the kinetic energy and the potential energy?

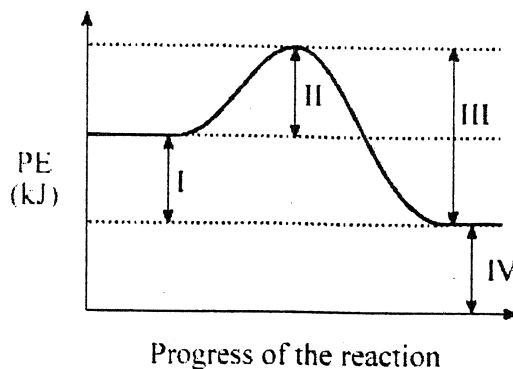
	Kinetic Energy	Potential Energy
A.	decreasing	decreasing
B.	decreasing	increasing
C.	increasing	increasing
D.	increasing	decreasing

B6. draw and label PE diagrams for both exothermic and endothermic reactions, including ΔH , activation energy, and the energy of the activated complex

0104-MC4-B6

4. Consider the following PE diagram:

(1 mark)



The activation energy for the forward reaction is represented by

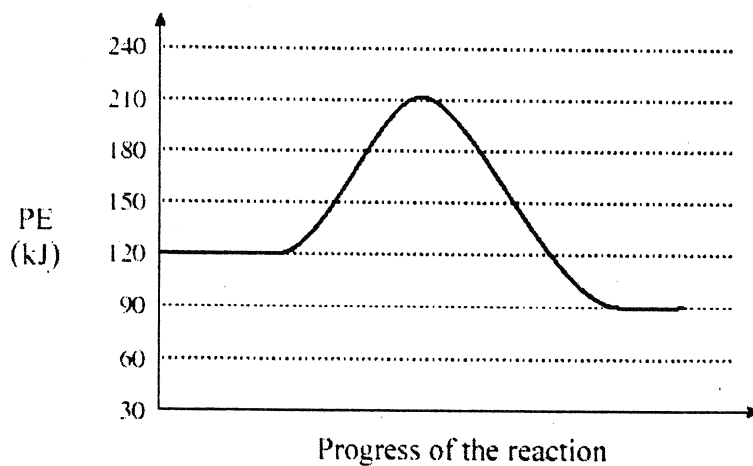
- A. I
- B. II
- C. III
- D. IV

B7. relate the sign of ΔH to whether the reaction is exothermic or endothermic

0108-MC5-B7

5. Consider the following potential energy diagram for a reaction:

(1 mark)



What is the value of ΔH for this reaction?

- A. -120 kJ
- B. -30 kJ
- C. +30 kJ
- D. +120 kJ

B8. write a chemical equation including the energy term (given a ΔH value) and vice versa
0106-MC4-B8

4. Which of the following reactions is endothermic?

(1 mark)

- A. $\text{CH}_4(g) + 2\text{O}_2(g) \rightarrow \text{CO}_2(g) + 2\text{H}_2\text{O}(l) + 890.3 \text{ kJ}$
 B. $2\text{Na}_2\text{O}_2(s) + 2\text{H}_2\text{O}(l) - 287.0 \text{ kJ} \rightarrow 4\text{NaOH}(aq) + \text{O}_2(g)$
 C. $\text{CaO}(s) + \text{H}_2\text{O}(l) \rightarrow \text{Ca}(\text{OH})_2(aq) \quad \Delta H = -65.2 \text{ kJ}$
 D. $\text{CaO}(s) + 3\text{C}(s) \rightarrow \text{CaC}_2(s) + \text{CO}(g) \quad \Delta H = +464.8 \text{ kJ}$

B9. describe the role of the following factors in reaction rate:

- nature of reactants
- concentration
- temperature
- surface area

0001-MC5-B9

5. Increasing the temperature of a reaction increases the reaction rate by

I.	increasing frequency of collisions
II.	increasing the kinetic energy of collision
III.	decreasing the potential energy of collision

- A. I only.
 B. I and II only.
 C. II and III only.
 D. I, II and III.

Reaction Mechanisms and Catalysts

C1. use examples to demonstrate that most reactions involve more than one step

No Examples Found!

C2. describe a reaction mechanism as the series of steps (collisions) that result in the overall reaction

9901-W1-C2

1. Consider the following reaction mechanism:

Step 1	?
Step 2	$\text{H}_2 + \text{Cl} \rightarrow \text{HCl} + \text{H}$
Step 3	$\text{H} + \text{Cl}_2 \rightarrow \text{HCl} + \text{Cl}$
Step 4	$\text{Cl} + \text{Cl} \rightarrow \text{Cl}_2$
Overall	$\text{H}_2 + \text{Cl}_2 \rightarrow 2\text{HCl}$

a) Write the equation for Step 1.

(2 marks)

b) Identify the reaction intermediate(s).

(1 mark)

C3. define *catalyst*

0101-MC6-C3

6. A substance that increases the rate of a reaction without appearing in the equation for the overall reaction is a(n)

(1 mark)

- A. product.
- B. catalyst.
- C. reactant.
- D. intermediate.

C4. compare and contrast the PE diagrams for a catalyzed and uncatalyzed reaction in terms of:

- reaction mechanism

- ΔH

- activation energy

0108-MC4-C4

4. What happens to the activation energy and ΔH when a catalyst is added to a reaction?

(2 marks)

	Activation Energy	ΔH
A.	increases	remains the same
B.	increases	increases
C.	decreases	remains the same
D.	decreases	decreases

C5. identify reactant, product, reaction intermediate, and catalyst from a given reaction mechanism

0108-MC6-C5

6. A substance that is produced in one step in a reaction mechanism and consumed in a subsequent step, without appearing in the overall reaction, is a(n)

(1 mark)

- A. catalyst.
- B. product.
- C. reactant.
- D. intermediate.

C6. describe the uses of specific catalysts in a variety of situations

No Examples Found!

2. DYNAMIC EQUILIBRIUM

Introduction

D1. describe the reversible nature of most chemical reactions

0004-MC7-D1,4

7. Which of the following applies to a chemical equilibrium?

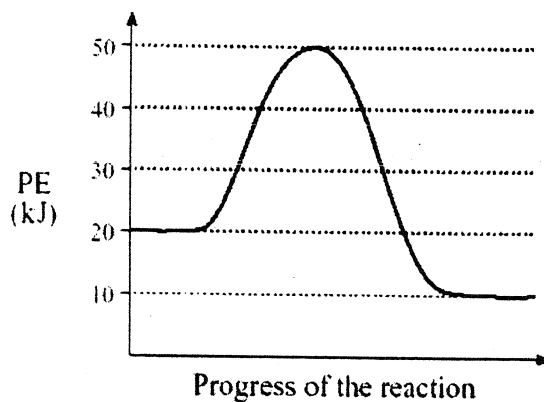
I.	Forward and reverse reaction rates are equal
II.	Equilibrium can be achieved from either direction
III.	Macroscopic properties are constant

- A. I only
- B. I and II only
- C. II and III only
- D. I, II and III

D2. identify the reversible pathways of a chemical reaction on the PE diagram

9904-MC7-D2

7. Consider the following PE diagram for a reversible reaction:



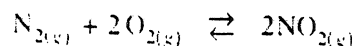
Which of the following describes this reaction?

	DIRECTION	ACTIVATION ENERGY (kJ)	ΔH (kJ)
A.	reverse	30	-10
B.	forward	40	-10
C.	forward	30	+10
D.	reverse	40	+10

D3. relate the changes in rates of the forward and reverse reactions to the changing concentrations of the reactants and products as equilibrium is established

0001-MC7-D3

7. Consider the following equilibrium:



Equal moles of N_2 and O_2 are added, under certain conditions, to a closed container. Which of the following describes the changes in the reverse reaction which occur as the system proceeds toward equilibrium?

	Rate of Reverse Reaction	$[\text{NO}_2]$
A.	increases	increases
B.	decreases	increases
C.	increases	decreases
D.	decreases	decreases

D4. describe chemical equilibrium as a closed system at constant temperature:

- whose macroscopic properties are constant
- where the forward and reverse reaction rates are equal
- that can be achieved from either direction
- where the concentrations of reactants and products are constant

9804-MC5-D4

5. Consider the following:

I	forward and reverse rates are equal
II	macroscopic properties are constant
III	can be achieved from either direction
IV	concentrations of reactants and products are equal

Which of the above are true for all equilibrium systems?

- A. I and II only
- B. I and IV only
- C. I, II and III only
- D. II, III and IV only

D5. describe the dynamic nature of chemical equilibrium

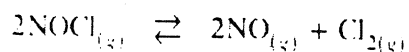
9801-MC5-D5

5. Chemical equilibrium is said to be dynamic because

- A. the reaction proceeds quickly.
- B. the mass of the reactants is decreasing.
- C. the macroscopic properties are constant.
- D. both forward and reverse reactions are occurring.

D6. infer that a system not at equilibrium will tend to move toward a position of equilibrium
 0006-MC7-D6

7. Consider the following equilibrium:



A flask of fixed volume is initially filled with $\text{NOCl}_{(g)}$, $\text{NO}_{(g)}$ and $\text{Cl}_{2(g)}$. When equilibrium is reached, the pressure has increased. To reach equilibrium, the reaction proceeded to the

- A. left because Trial K_{eq} was less than K_{eq} .
- B. right because Trial K_{eq} was less than K_{eq} .
- C. left because Trial K_{eq} was greater than K_{eq} .
- D. right because Trial K_{eq} was greater than K_{eq} .

D7. determine entropy and enthalpy changes from a chemical equation (qualitatively)
 9804-MC6-D7

6. In which reaction is the enthalpy of the reactants greater than the enthalpy of the products?

- A. $\text{H}_2\text{O}_{(s)} \rightarrow \text{H}_2\text{O}_{(l)}$
- B. $\text{H}_2\text{O}_{(s)} \rightarrow \text{H}_2\text{O}_{(g)}$
- C. $\text{H}_2\text{O}_{(l)} \rightarrow \text{H}_2\text{O}_{(s)}$
- D. $\text{H}_2\text{O}_{(l)} \rightarrow \text{H}_2\text{O}_{(g)}$

D8. state that systems tend toward a position of minimum enthalpy and maximum randomness (entropy)
 0106-MC8-D8

8. The entropy of a system is a term used to describe

(1 mark)

- A. randomness.
- B. heat content.
- C. average kinetic energy.
- D. stored chemical energy.

D9. predict the result when enthalpy and entropy factors:

- both favour the products
- both favour the reactants
- oppose one another

0101-MC8-D9

8. From the following, select the situation where both enthalpy and entropy favour the reaction toward products:

(1 mark)

	Enthalpy	Entropy
A.	increasing	increasing
B.	increasing	decreasing
C.	decreasing	decreasing
D.	decreasing	increasing

Le Châtelier's Principle

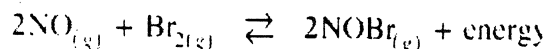
E1. describe the term *shift* as it applies to equilibrium
No examples found!

E2. apply Le Châtelier's principle to the shifting of equilibrium involving the following:
 - temperature change
 - concentration change
 - volume change of gaseous systems

0101-MC9-E2

9. Consider the following equilibrium:

(1 mark)



The equilibrium will shift to the left as a result of

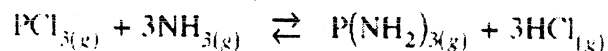
- A. adding a catalyst.
- B. adding some $\text{NO}_{(g)}$.
- C. increasing the volume.
- D. decreasing the temperature.

E3. explain the above shifts using the concepts of reaction kinetics

0101-MC10-E3

10. Consider the following equilibrium:

(2 marks)



The volume of the equilibrium system is increased and a new equilibrium is established.
 How have the rates been affected?

	Rate (forward)	Rate (reverse)
A.	increased	decreased
B.	decreased	increased
C.	decreased	decreased
D.	did not change	did not change

E4. identify the effect of a catalyst on dynamic equilibrium

9801-MC8-E4

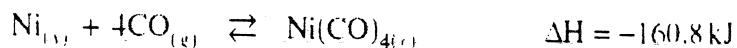
8. Addition of a catalyst to an equilibrium system

- A. increases the value of K_{eq} .
- B. increases the yield of products.
- C. has no effect on the rates of reaction.
- D. increases the rate of formation of both reactants and products.

E5. apply the concept of equilibrium to a commercial or industrial process
0106-MC10-E2,5

10. Consider the following equilibrium:

(1 mark)



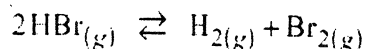
Which of the following will cause this equilibrium to shift to the left?

- A. add some CO
- B. decrease the volume
- C. remove some $\text{Ni}(\text{CO})_4$
- D. increase the temperature

The Equilibrium Constant

F1. gather and interpret data on the concentration of reactants and products of a system at equilibrium
9808-MC9-F1

9. Consider the following equilibrium:



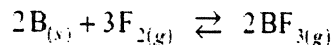
Initially, 0.100 mol HBr is placed into a 2.0 L container. At equilibrium, there are 0.040 mol HBr present. The equilibrium concentration of H_2 is

- A. 0.0050 mol/L
- B. 0.010 mol/L
- C. 0.015 mol/L
- D. 0.030 mol/L

F2. write the expression for the equilibrium constant when given the equation for either a homogeneous or heterogeneous equilibrium system

9801-MC9-F2

9. Consider the following reaction:



The equilibrium expression is

- A. $K_{eq} = \frac{[2\text{BF}_3]}{[3\text{F}_2]}$
- B. $K_{eq} = \frac{[\text{F}_2]^3}{[\text{BF}_3]^2}$
- C. $K_{eq} = \frac{[\text{BF}_3]^2}{[\text{F}_2]^3}$
- D. $K_{eq} = \frac{[\text{BF}_3]^2}{[\text{B}]^2[\text{F}_2]^3}$

F3. relate the equilibrium position to the value of K_{eq} and vice versa

0101-MC11-F3

11. Starting with equal moles of reactants, which of the following equilibrium systems most favours the reactants?

(1 mark)

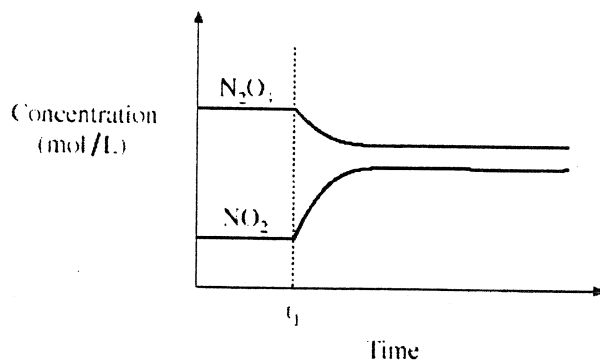
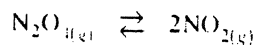
- A. $\text{SO}_{2(g)} + \text{NO}_{2(g)} \rightleftharpoons \text{SO}_{3(g)} + \text{NO}_{(g)}$ $K_{eq} = 3.4$
 B. $\text{CO}_{(g)} + \text{H}_2\text{O}_{(g)} \rightleftharpoons \text{CO}_{2(g)} + \text{H}_{2(g)}$ $K_{eq} = 31.4$
 C. $\text{H}_{2(g)} + \text{I}_{2(g)} \rightleftharpoons 2\text{HI}_{(g)}$ $K_{eq} = 10$
 D. $\text{N}_{2(g)} + \text{O}_{2(g)} \rightleftharpoons 2\text{NO}_{(g)}$ $K_{eq} = 1.0 \times 10^{-31}$

F4. predict the effect (or lack of effect) on the value of K_{eq} of changes in the following factors: temperature, pressure, concentration, surface area, and catalyst

0101-MC12-F4

12. Consider the following equilibrium reaction:

(2 marks)



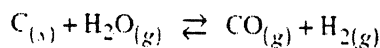
At time t_1 , heat is applied to the system. Which of the following best describes the equilibrium reaction and the change in K_{eq} ?

- A. exothermic and K_{eq} increases
 B. exothermic and K_{eq} decreases
 C. endothermic and K_{eq} increases
 D. endothermic and K_{eq} decreases

F5. calculate the value of K_{eq} given the equilibrium concentration of all species

9806-MC11-F5

11. Consider the following:



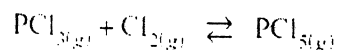
At equilibrium in a 1.0 L container, there are 1.60×10^{-2} mol C, 1.50×10^{-2} mol H_2O , 3.00×10^{-1} mol CO, and 1.00×10^{-1} mol H_2 . The value of K_{eq} is

- A. 0.500
 B. 2.00
 C. 80.0
 D. 125

F6. calculate the value of K_{eq} given the initial concentrations of all species and one equilibrium concentration

9801MC11-F6

11. Consider the following equilibrium:



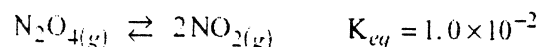
When 0.40 mol of PCl_3 and 0.40 mol of Cl_2 are placed in a 1.00 L container and allowed to reach equilibrium, 0.244 mol of PCl_5 are present. From this information, the value of K_{eq} is

- A. 0.10
- B. 0.30
- C. 3.3
- D. 10

F7. calculate the equilibrium concentrations of all species given the value of K_{eq} and the initial concentrations

9806-MC12-F7

12. Consider the following equilibrium:



At equilibrium, the $[\text{NO}_2] = 2.0 \times 10^{-2}$ mol/L and the $[\text{N}_2\text{O}_4]$ is

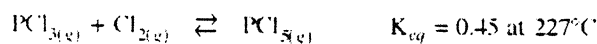
- A. 4.0×10^{-6} mol/L
- B. 4.0×10^{-2} mol/L
- C. 2.0 mol/L
- D. 25 mol/L

F8. determine whether a system is at equilibrium, and if not, in which direction it will shift to reach equilibrium when given a set of concentrations for reactants and products

0101-MC13-F8

13. Consider the following:

(1 mark)



Initially, a 1.00 L flask is filled with 0.100 mol PCl_3 , 0.100 mol Cl_2 , and 0.100 mol PCl_5 at 227°C . Use K_{Trial} to predict the change in $[\text{Cl}_2]$ as equilibrium is established.

	K_{Trial}	$[\text{Cl}_2]$
A.	$K_{Trial} > K_{eq}$	increases
B.	$K_{Trial} < K_{eq}$	increases
C.	$K_{Trial} > K_{eq}$	decreases
D.	$K_{Trial} < K_{eq}$	decreases

End of Chemistry 12 – Unit 2: Dynamic Equilibria Section

3. SOLUBILITY EQUILIBRIA

Concept of Solubility

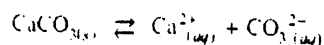
G1. classify solutions as ionic or molecular given the formula of the solute
9806-MC13-G1

13. Which of the following dissolves in water to form an ionic solution?

- A. O_2
- B. SiO_2
- C. $KMnO_4$
- D. $C_{12}H_{22}O_{11}$

G2. describe the conditions necessary to form a saturated solution
9904-MC15-G2

15. Consider the solubility equilibrium:



An additional piece of solid $CaCO_3$ is added to the equilibrium above.
The rate of dissolving and rate of crystallization have

	RATE OF DISSOLVING	RATE OF CRYSTALLIZATION
A.	increased	increased
B.	increased	not changed
C.	not changed	increased
D.	not changed	not changed

G3. describe solubility as the concentration of a substance in a saturated solution
0001-MC14-G3

14. Which of the following does **not** define solubility?

- A. the concentration of solute in a saturated solution
- B. the moles of solute dissolved in a given volume of solution
- C. the maximum mass of solute that can dissolve in a given volume of solution
- D. the minimum moles of solute needed to produce one litre of a saturated solution

G4. use appropriate units to represent the solubility of substances in aqueous solutions
9901-MC14-G4

14. Which of the following units could be used to describe solubility?

- A. g/s
- B. g/L
- C. M/L
- D. mol/s

G5. measure the solubility of a compound in aqueous solution
0006-MC14-G5

14. A saturated solution of $NaCl$ contains 36.5 g of solute in 0.100 L of solution.

The solubility of the compound is

- A. 0.062 M
- B. 1.60 M
- C. 3.65 M
- D. 6.24 M

G6. describe the equilibrium that exists in a saturated aqueous solution
9801-MC13-G6

13. When solid AgBr is added to a saturated solution of AgBr, the reaction rates can be described as:

	RATE OF DISSOLVING	RATE OF CRYSTALLIZATION
A.	increases	increases
B.	increases	decreases
C.	decreases	increases
D.	increases	no change

G7. write a net ionic equation that describes a saturated solution
0008-MC16-G7

16. The net ionic equation that describes a saturated solution of Ag_2CrO_4 is

- A. $\text{Ag}_2\text{CrO}_4(s) \rightleftharpoons \text{Ag}_2\text{CrO}_4(aq)$
 B. $\text{Ag}_2\text{CrO}_4(s) \rightleftharpoons 2\text{Ag}^+(aq) + \text{CrO}_4^{2-}(aq)$
 C. $\text{Ag}_2\text{CrO}_4(s) \rightleftharpoons 2\text{Ag}^+(aq) + \text{Cr}^{6+}(aq) + 4\text{O}^{2-}(aq)$
 D. $2\text{Ag}^+(aq) + \text{CrO}_4^{2-}(aq) + 2\text{H}_2\text{O}(l) \rightleftharpoons 2\text{AgOH}(s) + \text{H}_2\text{CrO}_4(aq)$

G8. calculate the concentration of the positive and negative ions given the concentration of a solute in an aqueous solution

0101-MC17-G8

17. The concentrations of the cation and anion in 0.40 M $(\text{NH}_4)_2\text{Cr}_2\text{O}_7(aq)$ are

	Cation	Anion
A.	0.40 M	0.40 M
B.	0.40 M	0.80 M
C.	0.80 M	0.40 M
D.	0.80 M	0.80 M

Solubility and Precipitation

H1. describe a compound as having high or low solubility relative to 0.1 M by using a solubility chart
9806-MC15-H1

15. Which of the following is most soluble?

- A. Na_2S
 B. CaSO_4
 C. PbCO_3
 D. $\text{Zn}(\text{OH})_2$

H2. use a solubility chart to predict if a precipitate will form when two solutions are mixed, and identify the precipitate

9808-MC15-H2

15. Which of the following 0.20 M solutions will **not** form a precipitate when mixed with an equal volume of 0.20 M $\text{Sr}(\text{OH})_2$?

- A. CaS
- B. NH_4Cl
- C. Na_2SO_4
- D. $\text{Ba}(\text{NO}_3)_2$

H3. write a formula equation, complete ionic equation, and net ionic equation that represent a precipitation reaction

9901-MC16-H3

16. When equal volumes of 0.20 M CuSO_4 and 0.20 M Li_2S are combined, the complete ionic equation is

- A. $\text{Cu}^{2+}_{(aq)} + \text{S}^{2-}_{(aq)} \rightarrow \text{CuS}_{(s)}$
- B. $\text{CuSO}_{4(aq)} + \text{Li}_2\text{S}_{(aq)} \rightarrow \text{CuS}_{(s)} + \text{Li}_2\text{SO}_{4(aq)}$
- C. $\text{Cu}^{2+}_{(aq)} + \text{SO}_4^{2-}_{(aq)} + 2\text{Li}^+_{(aq)} + \text{S}^{2-}_{(aq)} \rightarrow \text{Li}_2\text{SO}_{4(aq)} + \text{CuS}_{(s)}$
- D. $\text{Cu}^{2+}_{(aq)} + \text{SO}_4^{2-}_{(aq)} + 2\text{Li}^+_{(aq)} + \text{S}^{2-}_{(aq)} \rightarrow \text{CuS}_{(s)} + 2\text{Li}^+_{(aq)} + \text{SO}_4^{2-}_{(aq)}$

H4. use a solubility chart to predict if ions can be separated from solution through precipitation, and outline the process

0006-MC17-H4

17. A solution contains both Ag^+ and Mg^{2+} ions. During selective precipitation, these ions are removed one at a time by adding

- A. I^- followed by OH^-
- B. OH^- followed by S^{2-}
- C. SO_4^{2-} followed by Cl^-
- D. NO_3^- followed by PO_4^{3-}

H5. predict qualitative changes in the solubility equilibrium upon the addition of a common ion

0008-MC19-H5

19. The solute AgBr is least soluble in

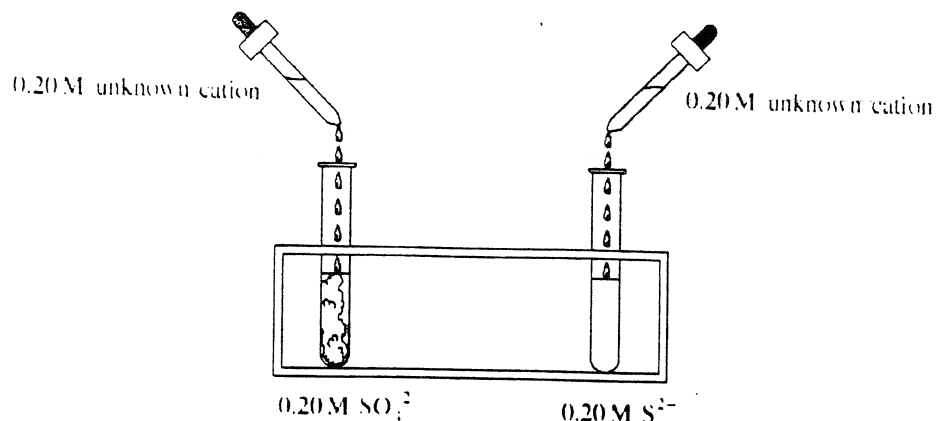
- A. H_2O
- B. 1.0 M FeBr_3
- C. 1.0 M CaBr_2
- D. 1.0 M AgNO_3

H6. identify an unknown ion through experimentation involving a qualitative analysis scheme

0104-MC19-H6

19. A precipitate forms when a 0.20 M solution containing an unknown cation is added to SO_4^{2-} , but not when an equal volume is added to S^{2-} .

(2 marks)



The unknown cation is

- A. Na^+
 - B. Ca^{2+}
 - C. Pb^{2+}
 - D. Zn^{2+}
- H7.** devise a procedure by which the contaminating ions in hard or polluted water can be removed
9808-MC17-H7
17. Two ions found in hard water are Ca^{2+} and Mg^{2+} . Which of the following will precipitate only one of these ions?
- A. I^-
 - B. S^{2-}
 - C. SO_4^{2-}
 - D. CO_3^{2-}

Quantitative Aspects

I1. describe the K_{sp} expression as a specialized K_{eq} expression
9806MC17-I1

17. Which of the following saturated solutions has the lowest $[\text{SO}_4^{2-}]$ at 25°C ?

- A. SrSO_4
- B. PbSO_4
- C. CaSO_4
- D. BaSO_4

I2. write a K_{sp} expression for a solubility equilibrium
9901-MC17-I2

17. The K_{sp} expression for a saturated solution of Ag_2CO_3 is

A. $K_{sp} = [\text{Ag}_2][\text{CO}_3^2]$

B. $K_{sp} = [\text{Ag}^+]^2[\text{CO}_3^2]$

C. $K_{sp} = [2\text{Ag}^+][\text{CO}_3^2]$

D. $K_{sp} = [2\text{Ag}^+]^2[\text{CO}_3^2]$

I3. calculate the K_{sp} for AB and AB₂ type compounds when given the solubility of a compound
9901-MC18-I3

18. The solubility of FeF_2 is 8.4×10^{-3} M. The K_{sp} value is

A. 5.9×10^{-7}

B. 2.4×10^{-6}

C. 7.1×10^{-5}

D. 8.4×10^{-3}

I4. calculate the solubility of AB and AB₂ type compounds from the K_{sp}
9904-MC20-I4

20. The solubility of SrF_2 is

A. 4.3×10^{-4} M

B. 6.6×10^{-5} M

C. 1.0×10^{-3} M

D. 1.6×10^{-3} M

I5. predict the formation of a precipitate by comparing the trial ion product to the K_{sp} value using specific data

9901-MC19-I5

19. If the Trial Ion Product for AgBrO_3 is calculated to be 1.0×10^{-7} , then

A. a precipitate forms because the Trial Ion Product $> K_{sp}$

B. a precipitate forms because the Trial Ion Product $< K_{sp}$

C. no precipitate forms because the Trial Ion Product $> K_{sp}$

D. no precipitate forms because the Trial Ion Product $< K_{sp}$

I6. calculate the maximum concentration of one ion given the K_{sp} and the concentration of the other ion
9906-MC18-I6

18. The maximum $[\text{SO}_4^{2-}]$ that can exist in 1.0×10^{-3} M $\text{Ca}(\text{NO}_3)_2$ without a precipitate forming is

A. 7.1×10^{-5} M

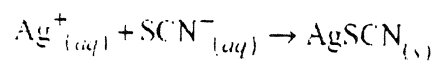
B. 1.0×10^{-3} M

C. 8.4×10^{-3} M

D. 7.1×10^{-2} M

I7. demonstrate and describe a method for determining the concentration of a specific ion
9806-W4-I7

4. Consider the following net ionic equation:



A 20.00 mL sample of 0.200 M NH_4SCN is used to titrate a 30.00 mL sample containing Ag^+ .
Calculate the $[\text{Ag}^+]$ in the original sample. (3 marks)

4. ACIDS, BASES, AND SALTS

Properties and Definitions

J1. identify acids and bases through experimentation ;

9906-MC19-J1

19. A 1.0×10^{-4} M solution has a pH of 10.00. The solute is a

- A. weak acid.
- B. weak base.
- C. strong acid.
- D. strong base.

J2. list general properties of acids and bases

9808-MC21-J2

21. Both acidic and basic solutions

- A. taste sour.
- B. feel slippery.
- C. conduct electricity.
- D. turn blue litmus red.

J3. write balanced equations representing the neutralization of acids by bases in solution

0108-MC21-J3

21. Which of the following reactions is not a neutralization reaction?

- A. $\text{KOH} + \text{HF} \rightarrow \text{KF} + \text{H}_2\text{O}$
- B. $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$
- C. $\text{Ca}(\text{OH})_2 + 2\text{HCl} \rightarrow \text{CaCl}_2 + 2\text{H}_2\text{O}$
- D. $\text{Na}_2\text{CO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + \text{CO}_2 + \text{H}_2\text{O}$

J4. define *Arrhenius acids and bases*

9908-MC22-J4

22. An Arrhenius acid is defined as a chemical species that

- A. is a proton donor.
- B. is a proton acceptor.
- C. produces hydrogen ions in solution.
- D. produces hydroxide ions in solution.

J5. write names and formulae of some common acids and bases and outline some of their common properties, uses, and commercial names

No Examples Found!

J6. define *Brønsted-Lowry acids and bases*

9804-MC21-J6

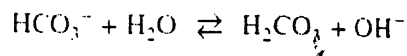
21. Which of the following could act as a Brønsted-Lowry acid, but not as a Brønsted-Lowry base?

- A. $\text{NH}_3(\text{aq})$
- B. $\text{H}_2\text{O}(\text{l})$
- C. $\text{HClO}_4(\text{aq})$
- D. $\text{HCO}_3^-(\text{aq})$

J7. identify Brønsted-Lowry acids and bases in an equation

9901-MC21-J7

21. Consider the following acid-base equilibrium:



In the reaction above, the Brønsted-Lowry acids are

- A. H_2O and OH^-
- B. HCO_3^- and OH^-
- C. H_2O and H_2CO_3
- D. HCO_3^- and H_2CO_3

J8. write balanced equations representing the reaction of acids or bases with water
0006-MC23-J8

23. The predominant acid-base reaction between H_2O_2 and H_2O is

- A. $\text{H}_2\text{O}_2 + \text{H}_2\text{O} \rightarrow 3\text{OH}^- + \text{H}^+$
- B. $\text{H}_2\text{O}_2 + \text{H}_2\text{O} \rightarrow 2\text{H}_2\text{O} + \text{O}^{2-}$
- C. $\text{H}_2\text{O}_2 + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}_2^+ + \text{OH}^-$
- D. $\text{H}_2\text{O}_2 + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{HO}_2^-$

J9. identify an H_3O^+ ion as a protonated H_2O molecule represented in shortened form as H^+ (aq)
0106-MC21-J9

21. A hydronium ion has the formula

- A. H_2^+
- B. OH^-
- C. H_2O^+
- D. H_3O^+

J10. define *conjugate acid-base pair*

0008-W5-J10,J11

5. a) Define the term *Brønsted-Lowry conjugate acid-base pair*.

(1 mark)

b) Give an example of a conjugate acid-base pair.

(1 mark)

Acid: _____

Base: _____

J11. identify the conjugate of a given acid or base

9904-MC22-J11

22. The conjugate acid of HAsO_4^{2-} is

- A. H_3O^+
- B. AsO_4^{3-}
- C. H_3AsO_4
- D. H_2AsO_4^-

J12. show that in any Brønsted-Lowry acid-base equation there are two conjugate pairs present
9806-MC22-J12

22. The number of conjugate pairs in a Brønsted-Lowry acid-base equation is

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

Strong and Weak Acids and Bases

K1. relate electrical conductivity in a solution to the concentration of ions
9901-MC23-K1

23. The solution with the lowest electrical conductivity is

- A. 0.10 M H_2S
- B. 0.10 M HNO_2
- C. 0.10 M H_2SO_3
- D. 0.10 M NH_4Cl

K2. classify an acid or base in solution as either weak or strong by comparing conductivity
0108-MC23-K2

23. Which of the following would be the same when comparing equal volumes of 1.0 M HBr and 1.0 M CH_3COOH ?

- A. the pH
- B. the electrical conductivity
- C. the titration curve for reaction with a base
- D. the moles of base required for neutralization

K3. define a *strong acid* and a *strong base*

9804-MC22-K3

22. The strength of an acid depends upon its

- A. E°
- B. pH
- C. concentration.
- D. degree of ionization.

K4. define a *weak acid* and a *weak base*

0101-MC24-K4

24. Which of the following statements applies to 1.0 M $\text{NH}_3(aq)$ but not to 1.0 M $\text{NaOH}(aq)$?

- A. partially ionizes
- B. neutralizes an acid
- C. has a pH greater than 7
- D. turns bromocresol green from yellow to blue

(1 mark)

K5. write equations to show what happens when strong and weak acids and bases are dissolved in water (dissociation, ionization)

9908-MC24-K5

24. An equation representing the reaction of a weak acid with water is

- A. $\text{HCl} + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{Cl}^-$
- B. $\text{NH}_3 + \text{H}_2\text{O} \rightleftharpoons \text{NH}_4^+ + \text{OH}^-$
- C. $\text{HCO}_3^- + \text{H}_2\text{O} \rightleftharpoons \text{H}_2\text{CO}_3 + \text{OH}^-$
- D. $\text{HCOOH} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{HCOO}^-$

K6. compare the relative strengths of acids or bases by using a table of relative acid strengths

9806-MC23-K6

23. Which of the following is a stronger base than HPO_4^{2-} ?

- A. H_2O
- B. NO_2^-
- C. CO_3^{2-}
- D. H_2PO_4^-

K7. identify and explain why the strongest acid in aqueous solutions is H_3O^+ and the strongest base in aqueous solutions is OH^-

9801-MC23-K7

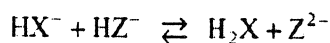
23. The strongest acid that can exist in an aqueous solution is

- A. NH_2^-
- B. H_3O^+
- C. HNO_2
- D. HClO_4

K8. predict whether products or reactants are favoured in an acid-base equilibrium by comparing the strength of the two acids (or two bases)

9804-MC24-K8

24. Consider the following equilibrium:



The reactants are favoured. The strongest acid is

- A. Z^{2-}
- B. HZ^-
- C. HX^-
- D. H_2X

K9. compare the relative concentrations of H_3O^+ (or OH^-) between two acids (or between two bases) using their relative positions on an acid strength table

0006-MC25-K9

25. Which of the following 1.0 M solutions will have the lowest $[\text{H}_3\text{O}^+]$?

- A. H_2S
- B. HNO_2
- C. H_2CO_3
- D. CH_3COOH

K10. define *amphiprotic*

0001-W7-K10,K11

7. Define the term *amphiprotic*. Give an example of an ion which is amphiprotic. (2 marks)

Definition: _____

Example: _____

K11. identify chemical species that are amphiprotic

9808-MC24-K11

24. Which of the following are amphiprotic in aqueous solution?

I	HBr
II	H_2O
III	HCO_3^-
IV	$\text{H}_2\text{C}_6\text{H}_5\text{O}_7^-$

- A. I and II only
- B. III and IV only
- C. II, III and IV only
- D. I, II, III and IV

K12. describe situations in which H_2O would act as an acid or base

0004-MC25-K12

25. Water acts as an acid when it reacts with which of the following?

I.	CN^-
II.	NH_3
III.	HClO_4
IV.	CH_3COO^-

- A. I and IV only
- B. II and III only
- C. I, II and IV only
- D. II, III and IV only

K_w , pH, and pOH

L1. write equations representing the ionization of water using either H_3O^+ and OH^- or H^+ and OH^-
0008-MC25-L1

25. Which of the following represents the ionization of water?

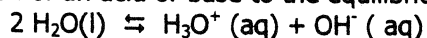
- A. $\text{H}_2\text{O} \rightleftharpoons \text{H}_2 + \frac{1}{2}\text{O}_2$
- B. $2\text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{OH}^-$
- C. $2\text{H}_2\text{O} + \text{O}_2 \rightleftharpoons 2\text{H}_2\text{O}_2$
- D. $\text{H}_2\text{O} \rightleftharpoons \frac{1}{2}\text{O}_2 + 2\text{H}^+ + 2\text{e}^-$

L2. write the equilibrium expression for the ion product constant of water, K_w
9806-MC25-L2

25. The equilibrium expression for the ion product constant of water is

- A. $K_w = [\text{H}_3\text{O}^+][\text{OH}^-]$
- B. $K_w = \frac{1}{[\text{H}_3\text{O}^+][\text{OH}^-]}$
- C. $K_w = \frac{[\text{H}_2\text{O}]^2}{[\text{H}_3\text{O}^+][\text{OH}^-]}$
- D. $K_w = \frac{[\text{H}_3\text{O}^+][\text{OH}^-]}{[\text{H}_2\text{O}]^2}$

L3. predict the effect of the addition of an acid or base to the equilibrium system:



9906-MC26-L3

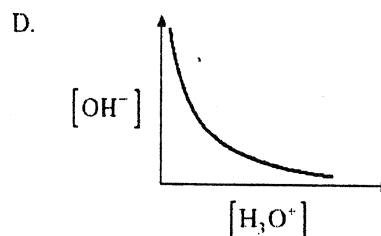
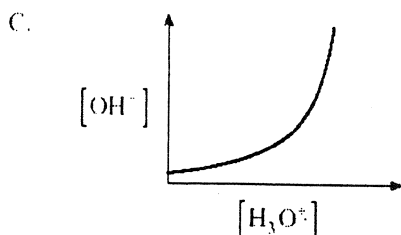
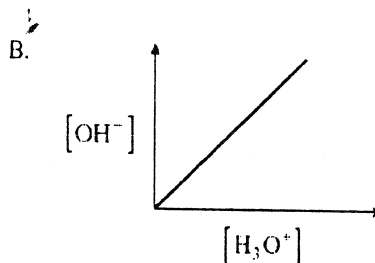
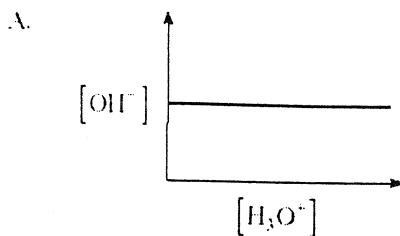
26. Addition of HCl to water causes

- A. both $[\text{H}_3\text{O}^+]$ and $[\text{OH}^-]$ to increase.
- B. both $[\text{H}_3\text{O}^+]$ and $[\text{OH}^-]$ to decrease.
- C. $[\text{H}_3\text{O}^+]$ to increase and $[\text{OH}^-]$ to decrease.
- D. $[\text{H}_3\text{O}^+]$ to decrease and $[\text{OH}^-]$ to increase.

L4. state the relative concentrations of H_3O^+ and OH^- in acid, base, and neutral solutions

9906-MC27-L4

27. Which of the following graphs describes the relationship between $[H_3O^+]$ and $[OH^-]$ in aqueous solutions at a constant temperature?



L5. state the value of K_w at 25°C

9808-MC25-L5

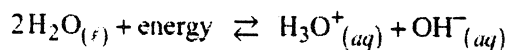
25. What is the value of K_w at 25°C ?

- A. 1.0×10^{-14}
- B. 1.0×10^{-7}
- C. 7
- D. 14

L6. describe the variation of the value of K_w with temperature

9806-MC27-L6

27. Consider the following equilibrium:



When the temperature of water is changed, the pH decreases. Which of the following explains this pH change?

- A. Temperature and K_w both increase.
- B. Temperature and K_w both decrease.
- C. Temperature increases and K_w decreases.
- D. Temperature decreases and K_w increases.

L7. calculate the concentration of H_3O^+ (or OH^-) given the other, using K_w

9801-MC26-L7

26. The $[H_3O^+]$ in 100.0 mL of 0.015 M KOH is

- A. 6.7×10^{-13}
- B. 6.7×10^{-12}
- C. 1.5×10^{-3}
- D. 1.5×10^{-2}

L8. describe the pH scale with reference to everyday solutions
No Examples Found!

L9. define *pH* and *pOH*

9804-MC27-L9

27. The relationship between *pOH* and $[\text{OH}^-]$ is

- A. $-\log \text{pOH} = [\text{OH}^-]$
- B. $\text{pOH} = -\log[\text{OH}^-]$
- C. $\text{antilog pOH} = [\text{OH}^-]$
- D. $\text{pOH} = \text{antilog}(-[\text{OH}^-])$

L10. define pK_w , give its value at 25°C, and its relation to *pH* and *pOH*

9901-MC26-L10

26. The value of pK_w at 25°C is

- A. 1.0×10^{-14}
- B. 1.0×10^{-7}
- C. 7.00
- D. 14.00

L11. perform calculations relating *pH*, *pOH*, H_3O^+ , and OH^-

9804-MC28-L11

28. The *pH* of a 0.025 M NaOH solution is

- A. 0.94
- B. 1.60
- C. 12.40
- D. 13.06

L12. calculate H_3O^+ or OH^- from *pH* and *pOH*

9806-MC28-L12

28. The $[\text{H}_3\text{O}^+]$ of a solution with a *pOH* of 4.60 is

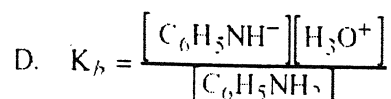
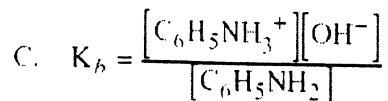
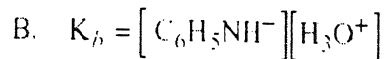
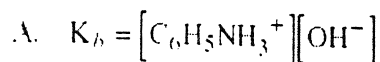
- A. 4.0×10^{-10} M
- B. 2.5×10^{-5} M
- C. 6.6×10^{-1} M
- D. 9.7×10^{-1} M

***K_a* and *K_b* Problem Solving**

M1. write *K_a* and *K_b* equilibrium expressions

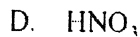
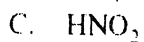
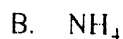
9806-MC29-M1

29. The K_b expression for aniline, $C_6H_5NH_2$, is



M2. relate the magnitude of K_a or K_b to the strength of the acid or base
9804-MC29-M2

29. Which is the weakest of the following acids?



M3. given the K_a , K_b , and initial concentration, calculate any of the following: H_3O^+ , OH^- , pH and pOH

9901-W5-M3

5. Calculate the pH of 0.50 M H_3BO_3 .

(4 marks)

M4. calculate the value of K_b for a base given the value of K_a for its conjugate acid (or vice versa)

9801-MC29-M4

29. The value of K_b for HPO_4^{2-} is

A. 2.2×10^{-13}

B. 6.2×10^{-8}

C. 1.6×10^{-7}

D. 4.5×10^{-2}

M5. calculate the value of K_a or K_b given the pH and initial concentration
9808-W6-M5

6. A 3.50×10^{-3} M sample of the unknown acid, HA, has a pH of 2.90.
Calculate the value of K_a and identify this acid.

(4 marks)

Hydrolysis of Salts

N1. write a dissociation equation for a salt in water

0006-W7-N1,N2,N3

7. Consider the salt ammonium acetate, $\text{NH}_4\text{CH}_3\text{COO}$.

a) Write the equation for the dissociation of $\text{NH}_4\text{CH}_3\text{COO}$.

(1 mark)

b) Write equations for the hydrolysis reactions which occur.

(2 marks)

c) Explain why a solution of $\text{NH}_4\text{CH}_3\text{COO}$ has a pH = 7.00.
Support your answer with calculations.

(2 marks)

N2. write net ionic equations representing the hydrolysis of salts
9904-MC29-N2

29. The net ionic equation for the hydrolysis of NH_4ClO_4 is

- A. $\text{NH}_4\text{ClO}_{4(s)} \rightleftharpoons \text{NH}_4^+_{(aq)} + \text{ClO}_4^-_{(aq)}$
- B. $\text{NH}_4^+_{(aq)} + \text{H}_2\text{O}_{(l)} \rightleftharpoons \text{NH}_3_{(aq)} + \text{H}_3\text{O}^+_{(aq)}$
- C. $\text{ClO}_4^-_{(aq)} + \text{H}_2\text{O}_{(l)} \rightleftharpoons \text{HClO}_{4(aq)} + \text{OH}^-_{(aq)}$
- D. $\text{NH}_4^+_{(aq)} + \text{ClO}_4^-_{(aq)} \rightleftharpoons \text{NH}_3_{(aq)} + \text{HClO}_{4(aq)}$

N3. predict qualitatively whether a salt solution would be acidic, basic, or neutral
9801-MC30-N3

30. Which of the following 0.10 M solutions is basic?

- A. LiCl
- B. K_3PO_4
- C. NaClO_4
- D. NH_4NO_3

N4. determine whether an amphiprotic ion will act as a base or an acid in solution
9804-MC30-N4

30. A solution of 0.10 M HSO_3^- will be

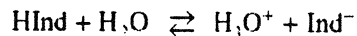
- A. basic because $K_a < K_b$
- B. acidic because $K_a < K_b$
- C. acidic because $K_a > K_b$
- D. neutral because $K_a = K_b$

Indicators

O1. describe an indicator as a mixture of a weak acid and its conjugate base, each with distinguishing colours

9908-MC31-O1

31. Consider the following equilibrium for an indicator:



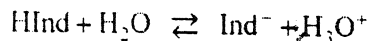
Which two species must be of two different colours in order to be used as an indicator?

- A. HInd and H_2O
- B. HInd and Ind^-
- C. H_3O^+ and Ind^-
- D. HInd and H_3O^+

O2. describe the term *transition point* of an indicator, including the conditions that exist in the equilibrium system

9804-MC31-O2

31. Consider the following equilibrium for the indicator phenol red:



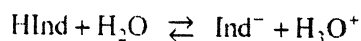
In a solution with a pH of 7.3, the indicator phenol red is

- A. red because $[\text{HInd}] < [\text{Ind}^-]$
- B. red because $[\text{HInd}] = [\text{Ind}^-]$
- C. yellow because $[\text{HInd}] > [\text{Ind}^-]$
- D. orange because $[\text{HInd}] = [\text{Ind}^-]$

03. describe the shift in equilibrium and resulting colour changes as an acid or a base is added to an indicator

9801-MC31-O3

31. Consider the following equilibrium for the indicator HInd at its transition point:



When a small amount of base is added, the equilibrium shifts to the

- A. left and the $[\text{HInd}] > [\text{Ind}^-]$
- B. left and the $[\text{HInd}] < [\text{Ind}^-]$
- C. right and the $[\text{HInd}] > [\text{Ind}^-]$
- D. right and the $[\text{HInd}] < [\text{Ind}^-]$

04. predict the approximate pH at the transition point using the K_a value of an indicator

9804-MC32-O4

32. The indicator with $K_a = 4 \times 10^{-8}$ is

- A. orange IV.
- B. neutral red.
- C. thymol blue.
- D. phenolphthalein.

05. predict the approximate K_a value for an indicator given the approximate pH range of the colour change

9801-MC32-O5

32. The approximate K_a value for the indicator thymolphthalein is

- A. 1×10^{-10}
- B. 1×10^{-4}
- C. 4
- D. 10

Neutralizations of Acids and Bases & Titration Curves

P1. demonstrate an ability to design and perform a neutralization experiment involving the following:

- primary standards
- standardized solutions
- titration curves

- indicators selected so the end point coincides with the equivalence point
9908-MC32-P1

32. Which of the following indicators is yellow at a pH of 10.0?

- A. methyl red
- B. phenol red
- C. thymol blue
- D. methyl violet

P2. calculate from titration data the concentration of an acid or base

9804-MC33-P2

33. A 25.0 mL sample of H_2SO_4 requires 25.0 mL of 0.100 M KOH for complete neutralization. The initial concentration of the H_2SO_4 is

- A. 5.00×10^{-2} M
- B. 1.00×10^{-1} M
- C. 2.00×10^{-1} M
- D. 4.00×10^{-1} M

P3. calculate the volume of an acid or base of known molarity needed to neutralize a known volume of a known molarity base or acid

9801-MC33-P3

33. What volume of 0.100 M NaOH is needed to completely neutralize 25.0 mL of 0.100 M H_2SO_4 ?

- A. 12.5 mL
- B. 25.0 mL
- C. 50.0 mL
- D. 75.0 mL

P4. write formula, complete ionic, and net ionic neutralization equations for:

- a strong acid by a strong base
- a weak acid by a strong base
- a strong acid by a weak base

9806-MC34-P4

34. The net ionic equation for the reaction between $\text{KOH}_{(aq)}$ and $\text{HBr}_{(aq)}$ is

- A. $\text{K}^+_{(aq)} + \text{Br}^-_{(aq)} \rightarrow \text{KBr}_{(s)}$
- B. $\text{H}^+_{(aq)} + \text{OH}^-_{(aq)} \rightarrow \text{H}_2\text{O}_{(l)}$
- C. $\text{KOH}_{(aq)} + \text{HBr}_{(aq)} \rightarrow \text{KBr}_{(aq)} + \text{H}_2\text{O}_{(l)}$
- D. $\text{K}^+_{(aq)} + \text{OH}^-_{(aq)} + \text{H}^+_{(aq)} + \text{Br}^-_{(aq)} \rightarrow \text{K}^+_{(aq)} + \text{Br}^-_{(aq)} + \text{H}_2\text{O}_{(l)}$

P5. calculate the pH of a solution formed when a strong acid is mixed with a strong base

9801-MC34-P5

34. When 0.10 mol of NaOH is added to 1.00 L of 0.30 M HCl, the pH of the resulting solution is

- A. 0.52
- B. 0.70
- C. 1.00
- D. 13.30

P6. contrast the equivalence point (stoichiometric point) of a strong acid-strong base titration with the equivalence point of a titration involving a weak acid-strong base or strong acid-weak base

9806-MC33-P6

33. When a 1.0 M acidic solution is titrated with a 1.0 M basic solution, the pH at the equivalence point is 8.5. The reactants could be

- A. HBr and KOH
- B. HNO₃ and NH₃
- C. HCl and NaOH
- D. HNO₂ and NaOH

Buffer Solutions

Q1. describe the tendency of buffer solutions to resist changes in pH

9906-MC35-Q1

35. Consider the following:

I.	H ₃ O ⁺
II.	CH ₃ COO ⁻
III.	CH ₃ COOH

The purpose of a buffer system consisting of CH₃COOH and CH₃COONa is to maintain a relatively constant concentration of

- A. I only.
- B. I and II only.
- C. II and III only.
- D. I, II and III.

Q2. describe the composition of an acidic buffer and a basic buffer

9804-MC35-Q2

35. A buffer solution can be prepared by combining, in water, equal moles of

- A. HF and KF
- B. HIO₃ and HI
- C. HBr and LiBr
- D. HClO₄ and NaOH

Q3. outline a procedure to prepare a buffer solution

9801-MC35-Q3

35. Which of the following could be used to form a buffer solution?

- A. HBr and NaOH
- B. HCl and NH₄Cl
- C. HNO₃ and NaNO₃
- D. H₂CO₃ and NaHCO₃

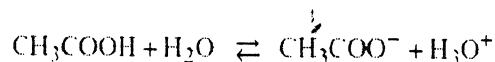
Q4. identify the limitations in buffering action

No Examples Found!

Q5. describe qualitatively how the buffer equilibrium shifts as small quantities of acid or base are added to the buffer

9806-MC35-Q5

35. Consider the following equilibrium for a buffer solution:



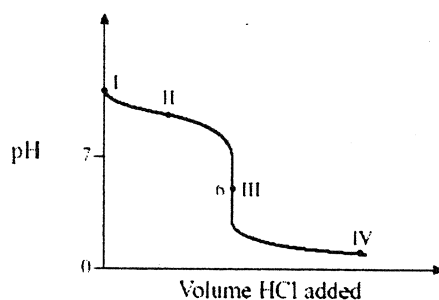
When a small amount of acid is added to this system, and equilibrium is reestablished,

- A. $[\text{CH}_3\text{COO}^-]$ and pH have both increased.
- B. $[\text{CH}_3\text{COOH}]$ and pH have both decreased.
- C. $[\text{CH}_3\text{COO}^-]$ has decreased and pH remains relatively constant.
- D. $[\text{CH}_3\text{COOH}]$ has decreased and pH remains relatively constant.

Q6. describe common buffer systems present in industrial, environmental, or biological systems

9908-MC35-Q6

35. Consider the following graph for the titration of 0.1M NH_3 with 0.1M HCl:



A buffer solution is present at point

- A. I
- B. II
- C. III
- D. IV

Acid Rain

R1. write equations representing the formation of acidic solutions or basic solutions from non-metal and metal oxides

9804-MC36-R1

36. Which of the following oxides will dissolve in water to form an acidic solution?

- A. SO_2
- B. TiO
- C. K_2O
- D. MgO

R2. describe the pH conditions required for rain to be called acid rain

9808-MC36-R2

36. Which of the following could be the pH of a sample of acid rain?

- A. 0
- B. 4
- C. 7
- D. 10

R3. relate the pH of normal rain water to the presence of dissolved CO₂
9801-MC36-R3

36. Normal rain has a pH of approximately 6 as a result of dissolved

- A. oxygen.
- B. carbon dioxide.
- C. sulphur dioxide.
- D. nitrogen dioxide.

R4. describe sources of NO_x and SO_x
0001-MC37-R4

37. A gas which is produced by internal combustion engines and contributes to the formation of acid rain is

- A. H₂
- B. O₃
- C. CH₄
- D. NO₂

R5. discuss general environmental problems associated with acid rain
No Examples Found!

End of Chemistry 12 – Unit 4: Acids, Bases, and Salts Section

5. OXIDATION-REDUCTION

Introduction

S1. define and apply the following: *oxidation; reduction; oxidizing agent; reducing agent; half-reaction; redox reaction*

9804-MC38-S1

38. When ClO_2 is oxidized, a possible product is

- A. Cl
- B. ClO
- C. ClO_2
- D. ClO_4

S2. determine the following:

- the oxidation number of an atom in a chemical species
- the change in oxidation number an atom undergoes when it is oxidized or reduced
- whether an atom has been oxidized or reduced by its change in oxidation number

9801-MC37-S2

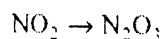
37. Which of the following represents a redox reaction?

- A. $\text{H}_2\text{CO}_3 \rightarrow \text{H}_2\text{O} + \text{CO}_2$
- B. $\text{CuS} + \text{H}_2 \rightarrow \text{H}_2\text{S} + \text{Cu}$
- C. $\text{AgNO}_3 + \text{NaCl} \rightarrow \text{AgCl} + \text{NaNO}_3$
- D. $2\text{HCl} + \text{Na}_2\text{SO}_3 \rightarrow 2\text{NaCl} + \text{H}_2\text{O} + \text{SO}_2$

S3. relate change in oxidation number to gain or loss of electrons

9904-MC39-S3

39. Consider the following:



The nitrogen atom in each NO_2

- A. loses one electron.
- B. gains one electron.
- C. loses two electrons.
- D. gains two electrons.

S4. from data for a series of simple redox reactions, create a simple table of reduction half-reactions

9808-MC41-S4

41. In an experiment to determine the relative strength of oxidizing agents, three metals, Ag, Ru and Pd were placed into solutions containing a cation of the other two metals. The results were recorded in the following data table:

SOLUTION METAL	Pd^{2+}	Ru^{2+}	Ag^+
Ag	reaction	no reaction	
Ru	reaction		reaction
Pd		no reaction	no reaction

The relative strength of oxidizing agents is

- A. $\text{Ru} > \text{Ag} > \text{Pd}$
- B. $\text{Pd} > \text{Ag} > \text{Ru}$
- C. $\text{Ru}^{2+} > \text{Ag}^+ > \text{Pd}^{2+}$
- D. $\text{Pd}^{2+} > \text{Ag}^+ > \text{Ru}^{2+}$

S5. identify the relative strengths of oxidizing and reducing agents from their positions on a half-reaction table

9901-MC39-S5

39. Which of the following is the strongest reducing agent?

- A. Al
- B. Cu
- C. Zn
- D. Mg

S6. use a table of reduction half-reactions to predict whether a spontaneous redox reaction will occur between any two species

9901-MC40-S6

40. Which of the following reactions is spontaneous at standard conditions?

- A. $\text{Pb} + \text{Cu}^{2+} \rightarrow \text{Cu} + \text{Pb}^{2+}$
- B. $\text{H}_2 + \text{Mg}^{2+} \rightarrow \text{Mg} + 2\text{H}^+$
- C. $\text{Br}_2 + 2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{Br}^-$
- D. $2\text{Ag} + \text{Cu}^{2+} \rightarrow \text{Cu} + 2\text{Ag}^+$

Balancing Redox Equations

T1. balance a half-reaction in solution (acid, base, neutral)

9906-MC41-T1

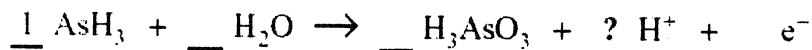
41. Which of the following half-reactions is balanced?

- A. $\text{ClO}^- + \text{H}_2\text{O} + \text{e}^- \rightarrow \text{Cl}_2 + 2\text{OH}^-$
- B. $2\text{ClO}^- + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Cl}_2 + 3\text{OH}^-$
- C. $2\text{ClO}^- + 2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Cl}_2 + 4\text{OH}^-$
- D. $2\text{ClO}^- + 2\text{H}_2\text{O} \rightarrow \text{Cl}_2 + 4\text{OH}^- + 2\text{e}^-$

T2. balance a net ionic redox reaction in acid and base solution

9904-MC41-T2

41. Consider the following half-reaction:



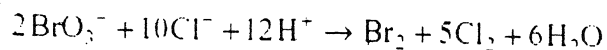
When this half-reaction equation is balanced, the coefficient for H^+ is

- A. 2
- B. 3
- C. 6
- D. 9

T3. write the equations for reduction and oxidation half-reactions given a redox reaction

9801-MC43-T3

43. Consider the redox reaction below:



The oxidation half-reaction involved in this reaction is

- A. $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$
- B. $2\text{H}^+ \rightarrow \text{H}_2 + 2\text{e}^-$
- C. $\text{BrO}_3^- + 6\text{H}^+ + 5\text{e}^- \rightarrow \frac{1}{2}\text{Br}_2 + 3\text{H}_2\text{O}$
- D. $\text{BrO}_3^- + 6\text{H}^+ \rightarrow \frac{1}{2}\text{Br}_2 + 3\text{H}_2\text{O} + 5\text{e}^-$

T4. identify reactants and products for several redox reactions performed in a laboratory and balance the equations

9804-MC43-T4

43. When H_2O_2 is added to an acidified MnO_4^- solution, a spontaneous reaction occurs in which a product of the oxidation reaction is

- A. O_2
- B. H_2O
- C. Mn^{2+}
- D. MnO_2

T5. select a suitable reagent to be used in a redox titration in order to determine the concentration of a species

9804-MC44-T5

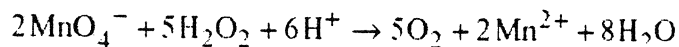
44. To determine the $[\text{Cr}_2\text{O}_7^{2-}]$ in a redox titration, a suitable reagent is

- A. Ni^{2+}
- B. Sn^{2+}
- C. Zn^{2+}
- D. Mg^{2+}

T6. determine the concentration of a species by performing a redox titration

9806-MC42-T6

42. Consider the following:



In an experiment, 2.00×10^{-4} mol of MnO_4^- is required to titrate 10.0 mL of H_2O_2 to the equivalence point. The concentration of H_2O_2 is

- A. 5.00×10^{-3} M
- B. 8.00×10^{-3} M
- C. 2.00×10^{-2} M
- D. 5.00×10^{-2} M

Electrochemical Cells

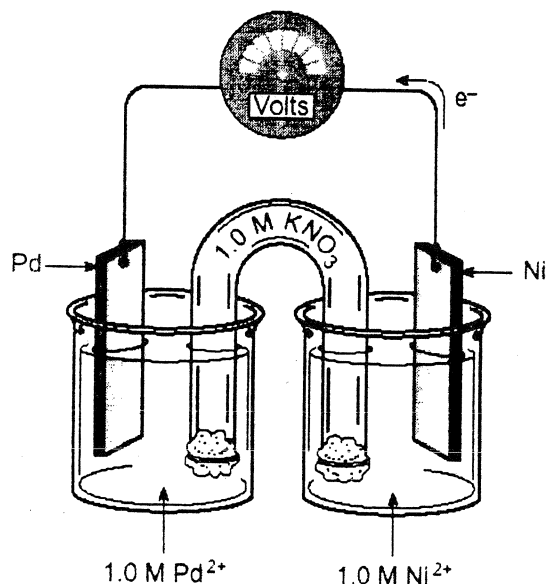
U1. define, construct, and label the parts of an electrochemical cell
0001-MC43-U1

43. In an operating electrochemical cell the function of a salt bridge is to

- A. allow hydrolysis to occur.
- B. allow a non-spontaneous reaction to occur.
- C. permit the migration of ions within the cell.
- D. transfer electrons from the cathode to the anode.

U2. identify the half-reactions that take place at each electrode
9801-MC44-U2

Use the following diagram to answer questions 44, 45 and 46.



44. As the cell operates, the electrons flow from the nickel electrode to the palladium electrode. The reaction occurring at the anode is

- A. $\text{Pd} \rightarrow \text{Pd}^{2+} + 2\text{e}^-$
- B. $\text{Ni} \rightarrow \text{Ni}^{2+} + 2\text{e}^-$
- C. $\text{Pd}^{2+} + 2\text{e}^- \rightarrow \text{Pd}$
- D. $\text{Ni}^{2+} + 2\text{e}^- \rightarrow \text{Ni}$

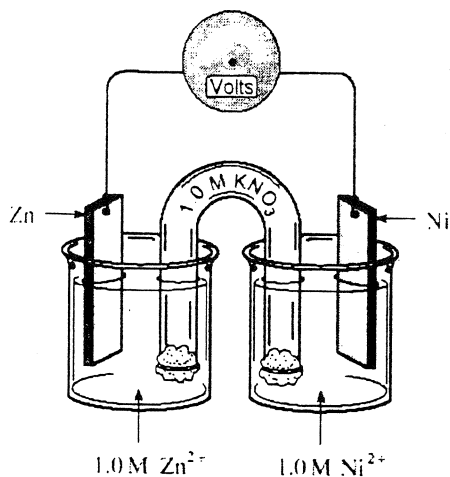
U3. predict the direction of movement of each type of ion in the cell
9801-MC45-U3 (Use diagram from previous question!)

45. As the cell operates,

- A. both the K^+ and the NO_3^- migrate into the nickel half-cell.
- B. both the K^+ and the NO_3^- migrate into the palladium half-cell.
- C. the K^+ migrates into the nickel half-cell and the NO_3^- migrates into the palladium half-cell.
- D. the K^+ migrates into the palladium half-cell and the NO_3^- migrates into the nickel half-cell.

U4. predict the direction of flow of electrons in an external circuit
 0004-MC45-U4,U5

45. Consider the following electrochemical cell:

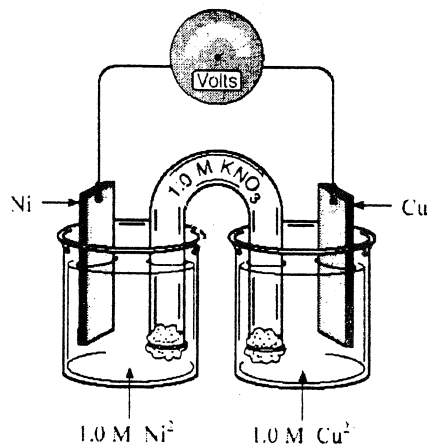


Which of the following occurs as the cell operates?

- A. Zinc electrode is reduced and increases in mass.
- B. Zinc electrode is reduced and decreases in mass.
- C. Zinc electrode is oxidized and increases in mass.
- D. Zinc electrode is oxidized and decreases in mass.

U5. predict which electrode will increase in mass and which will decrease in mass as the cell operates
 0008-MC45-U5

Use the following diagram to answer questions 45 and 46.

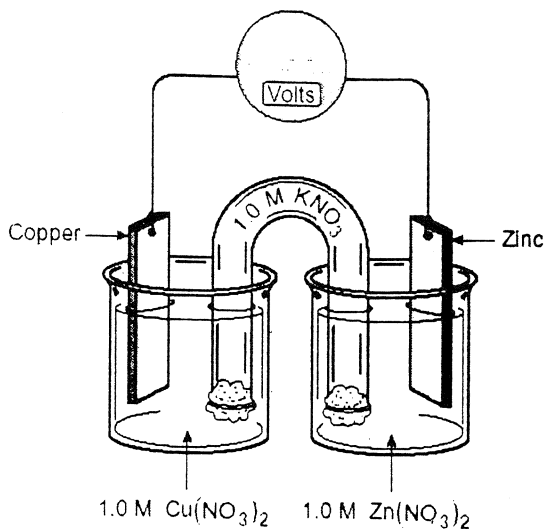


45. As the cell operates, observations include

	Mass of Nickel Electrode	Concentration of Copper Ions
A.	decreases	increases
B.	decreases	decreases
C.	increases	increases
D.	increases	decreases

U6. predict the voltage of the cell when equilibrium is reached
 9908-MC43-U6

Use the following diagram to answer questions 42 and 43.

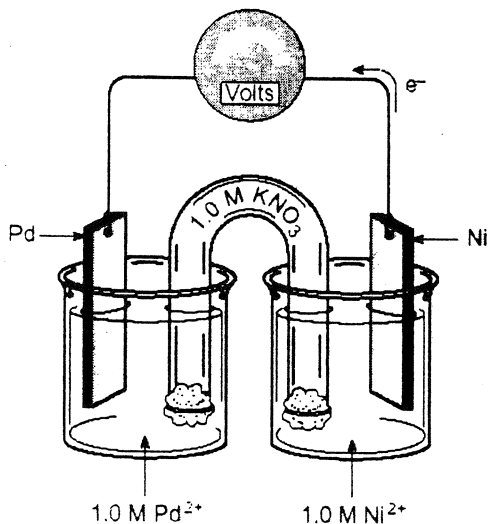


43. At equilibrium, the voltage of the cell above is

- A. -1.10 V
- B. 0.00 V
- C. $+0.42\text{ V}$
- D. $+1.10\text{ V}$

U7. assign voltages to the reduction half-reactions of oxidizing agents by comparison of several cells
 9801-MC46-U7

Use the following diagram to answer questions 44, 45 and 46.



46. The initial cell voltage is 1.21 V . The reduction potential of Pd^{2+} is

- A. -1.21 V
- B. -0.95 V
- C. $+0.95\text{ V}$
- D. $+1.21\text{ V}$

U8. describe the significance of the E° of an electrochemical cell

9901-MC44-U8

44. Which of the following affects the potentials of electrochemical cells?

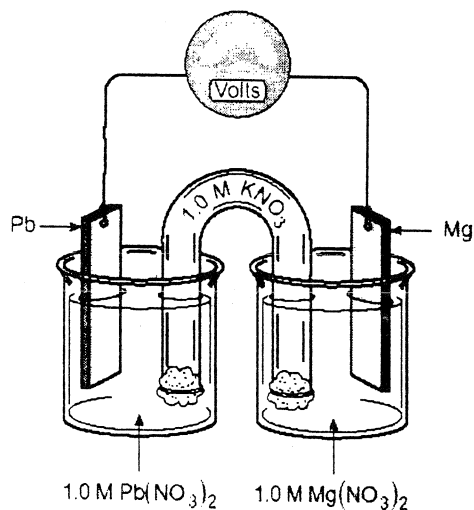
I.	species used as oxidizing agent
II.	temperature
III.	concentration of reactants

- A. I and II only.
- B. II and III only.
- C. I and III only.
- D. I, II and III.

U9. predict the voltage (E°) of an electrochemical cell using the table of standard reduction half-cells

9808-MC44-U9

Use the following diagram to answer questions 43, 44 and 45.



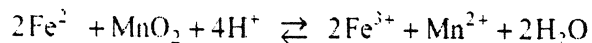
44. The E° of the cell above is

- A. -2.50 V
- B. -2.24 V
- C. $+2.24\text{ V}$
- D. $+2.50\text{ V}$

U10. predict the spontaneity of the forward or reverse reaction from the E° of a redox reaction

9804-MC42-U10

42. Consider the following redox reaction:

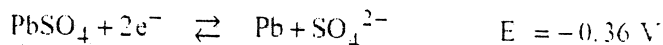
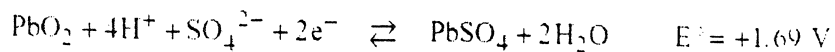


The forward reaction has a

- A. positive E° value and is spontaneous.
- B. negative E° value and is spontaneous.
- C. positive E° value and is nonspontaneous.
- D. negative E° value and is nonspontaneous.

U11. describe how electrochemical concepts can be used in various practical applications
9806-MC43-U11

43. A lead storage battery contains electrochemical cells which involve the following half-reactions:



Use the data above to calculate the E° for one of these cells.

- A. $E^\circ = +1.33 \text{ V}$
- B. $E^\circ = -1.33 \text{ V}$
- C. $E^\circ = -2.05 \text{ V}$
- D. $E^\circ = +2.05 \text{ V}$

Corrosion

V1. describe the conditions necessary for corrosion to occur
9801-MC47-V1

47. Consider the following chemicals:

I	water
II	oxygen gas
III	nitrogen gas

At 25°C , a piece of iron rusts in the presence of

- A. I only.
- B. III only.
- C. I and II only.
- D. II and III only.

V2. analyse the process of metal corrosion in electrochemical terms
9901-MC45-V2

45. In the rusting of iron, the reduction reaction that occurs is

- A. $\text{Fe} \rightarrow \text{Fe}^{2+} + 2\text{e}^-$
- B. $\text{Fe}^{2+} + 2\text{e}^- \rightarrow \text{Fe}$
- C. $2\text{H}_2\text{O} \rightarrow \text{O}_2 + 4\text{H}^+ + 4\text{e}^-$
- D. $\text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^- \rightarrow 4\text{OH}^-$

V3. suggest several methods of preventing or inhibiting corrosion of a metal
9901-MC46-V3

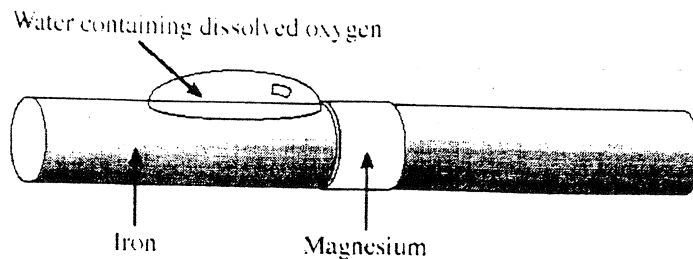
46. During a cathodic protection, the sacrificial anode

- A. accepts electrons from the protected metal.
- B. reacts spontaneously with the protected metal.
- C. oxidizes more readily than the protected metal.
- D. causes the protected metal to become an anode.

V4. describe and explain the principle of cathodic protection

0006-MC47-V4

47. Consider the following diagram of a piece of iron, cathodically protected by magnesium:



What is happening during this process?

- A. Iron acts as the anode and water is oxidized.
- B. Iron acts as the cathode and oxygen is reduced.
- C. Magnesium acts as the anode and iron is oxidized.
- D. Magnesium acts as the cathode and iron is reduced.

Electrolytic Cells

W1. define *electrolysis* and *electrolytic cell*

9906-MC48-W1

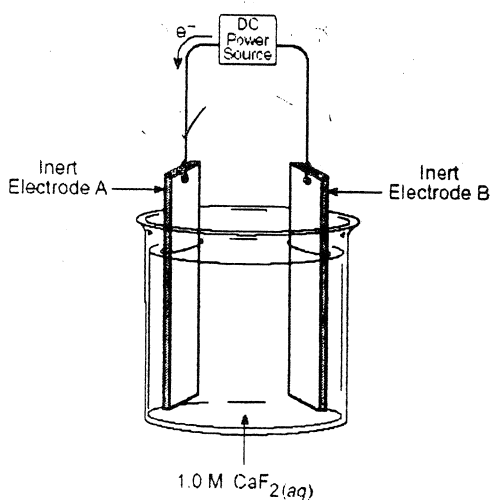
48. In order for an electrolytic cell to operate, it must have

- A. a voltmeter.
- B. a salt bridge.
- C. a power supply.
- D. an aqueous solution.

W2. design and label the parts of an electrolytic cell capable of electrolyzing an aqueous salt (use of overpotential effect not required)

9806-MC48-W2

Use the following diagram to answer questions 47 and 48.



48. In the electrolytic cell above, a suitable substance for Electrode B is

- A. carbon.
- B. lithium.
- C. sodium.
- D. calcium.

W3. predict the direction of flow of all ions in the cell

9908-MC47-W3

47. What substances are formed at the anode and cathode during electrolysis of molten sodium chloride, $\text{NaCl}_{(l)}$?

	ANODE	CATHODE
A.	O_2	H_2
B.	Na	Cl_2
C.	Cl_2	H_2
D.	Cl_2	Na

W4. write the half-reaction occurring at each electrode

9801-MC48-W4

48. During the electrolysis of 1.0 M Na_2SO_4 , the reaction at the cathode is

- A. $\text{Na}^+ + \text{e}^- \rightarrow \text{Na}$
 B. $2\text{SO}_4^{2-} \rightarrow \text{S}_2\text{O}_8^{2-} + 2\text{e}^-$
 C. $2\text{H}_2\text{O} \rightarrow \text{O}_2 + 4\text{H}^+ + 4\text{e}^-$
 D. $2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2 + 2\text{OH}^-$

W5. demonstrate the principles involved in simple electroplating

9901-MC48-W5

48. When electroplating an iron medallion with nickel,

- A. the medallion is an anode.
 B. the cathode is pure nickel.
 C. the solution contains Ni^{2+} .
 D. the anode reaction is $\text{Ni}^{2+} + 2\text{e}^- \rightarrow \text{Ni}$

W6. construct an electrolytic cell capable of electroplating an object

9904-MC47-W6

47. Why can an object **not** be plated with magnesium using 1.0 M MgI_2 ?

- A. Water is a stronger reducing agent than I^-
 B. Water is a stronger oxidizing agent than I^-
 C. Water is a stronger reducing agent than Mg^{2+}
 D. Water is a stronger oxidizing agent than Mg^{2+}

W7. describe the electrolytic aspects of metal refining processes

9908-MC48-W7

48. What is the minimum voltage required to form nickel from an aqueous solution of NiI_2 using inert electrodes?

- A. 0.26 V
 B. 0.28 V
 C. 0.54 V
 D. 0.80 V

W8. draw and label the parts of an electrolytic cell used for electrolysis of a molten binary salt

0006-W10-W8

10. Draw and label an electrochemical cell using a copper anode and having an E° value $> 1.00 \text{ V}$.
 (2 marks)