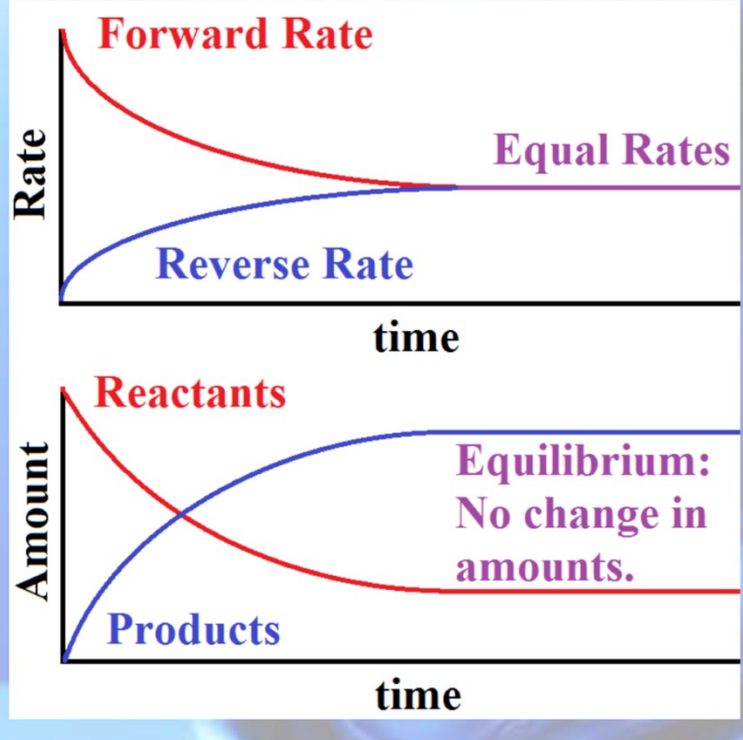
NGSS Regents Chemistry

PRACTICE PACKET

Unit 8: Kinetics & Equilibrium



Regents Chemistry **Rate of Reaction**

1. Why can an increase in temperature lead to more effective collisions between reactant particles and an increase in the rate of a chemical reaction?

   A) The activation energy of the reaction increases.

   B) The activation energy of the reaction decreases. catalyst

   C) The number of molecules with sufficient energy to react increases.

   D) The number of molecules with sufficient energy to react decreases.

2. Given the balanced equation representing a reaction:
   $Zn(s) + 2HCl(aq) \rightarrow H_2(g) + ZnCl_2(aq)$
   Which set of reaction conditions produces $H_2(g)$ at the fastest rate?

   A) a 1.0-g lump of Zn(s) in 50. mL of 0.5 M HCl(aq) at 20.°C

   B) a 1.0-g lump of Zn(s) in 50. mL of 0.5 M HCl(aq) at 30.°C

   C) 1.0 g of powdered Zn(s) in 50. mL of 1.0 M HCl(aq) at 20.°C

   D) 1.0 g of powdered Zn(s) in 50. mL of 1.0 M HCl(aq) at 30.°C

3. A catalyst is added to a system at equilibrium. If the temperature remains constant, the activation energy of the forward reaction

   A) decreases B) increases

   C) remains the same

Rate of Reaction

4. Given the reaction:

$A + B \rightarrow AB$

The table below shows student data obtained about the rate of reaction when the concentration of solution A is kept constant and the concentration of solution B is changed by adding H_2O. Based on the data, the student should conclude that the

Trial	Volume of Solution A	Volume of Solution B	Volume of H_2O Added	Reaction Time
1	10 mL	10 mL	0 mL	2.8 sec
2	10 mL	5 mL	5 mL	4.9 sec
3	10 mL	3 mL	7 mL	10.4 sec

A) concentration has no effect on the reaction rate
B) reaction rate increased when H_2O was added
C) reaction rate increased as solution B was diluted
D) reaction rate decreased as solution B was diluted

5. After being ignited in a Bunsen burner flame, a piece of magnesium ribbon burns brightly, giving off heat and light. In this situation, the Bunsen burner flame provides

A) ionization energy
B) activation energy
C) heat of reaction
D) heat of vaporization

6. An increase in the surface area of reactants in a heterogeneous reaction will result in

A) a decrease in the rate of the reaction
B) an increase in the rate of the reaction
C) a decrease in the heat of reaction
D) an increase in the heat of reaction

7. At 20.°C, a 1.2-gram sample of Mg ribbon reacts rapidly with 10.0 milliliters of 1.0 M HC1(aq). Which change in conditions would have caused the reaction to proceed more slowly?

A) increasing the initial temperature to 25°C
B) decreasing the concentration of HCl(aq) to 0.1 M
C) using 1.2 g of powdered Mg
D) using 2.4 g of Mg ribbon

8. Given the balanced equation representing a reaction:

$$Fe(s) + 2HCl(aq) \rightarrow FeCl_2(aq) + H_2(g)$$

This reaction occurs more quickly when powdered iron is used instead of a single piece of iron of the same mass because the powdered iron

A) acts as a better catalyst than the single piece of iron
B) absorbs less energy than the single piece of iron
C) has a greater surface area than the single piece of iron
D) is more metallic than the single piece of iron

Rate of Reaction

9. Each of four test tubes contains a different concentration of HCl(aq) at 25°C. A 1-gram cube of Zn is added to each test tube. In which test tube is the reaction occurring at the fastest rate?

A) 1 M HCl(aq) 10 mL

B) 0.1 M HCl(aq) 10 mL

C) 0.01 M HCl(aq) 10 mL

D) 0.001 M HCl(aq) 10 mL

10. As the concentration of reacting particles increases, the rate of reaction generally

A) decreases B) increases
C) remains the same

11. Which change would most likely increase the rate of a chemical reaction?

A) decreasing a reactant's concentration
B) decreasing a reactant's surface area
C) cooling the reaction mixture
D) adding a catalyst to the reaction mixture

12. Which statement best describes how a catalyst increases the rate of a reaction?

A) The catalyst provides an alternate reaction pathway with a higher activation energy.
B) The catalyst provides an alternate reaction pathway with a lower activation energy.
C) The catalyst provides the same reaction pathway with a higher activation energy.
D) The catalyst provides the same reaction pathway with a lower activation energy.

13. If the pressure on gaseous reactants is increased, the rate of reaction is increased because there is an increase in the

A) activation energy B) volume
C) concentration D) heat of reaction

14. A 1.0-gram piece of zinc reacts with 5 milliliters of HCl(aq). Which of these conditions of concentration and temperature would produce the greatest rate of reaction?

A) 1.0 M HCl(aq) at 20.°C
B) 1.0 M HCl(aq) at 40.°C
C) 2.0 M HCl(aq) at 20.°C
D) 2.0 M HCl(aq) at 40.°C

15. In a biochemical reaction, an enzyme acts as a catalyst, causing the

A) activation energy of the reaction to decrease
B) potential energy of the reactants to decrease
C) kinetic energy of the reactants to increase
D) heat of reaction to increase

16. Given the reaction:

$$A_2(g) + B_2(g) \leftrightarrow 2\,AB(g) + \text{heat}$$

An increase in the concentration of $A_2(g)$ will

A) decrease the production of $AB(g)$
B) decrease the frequency of collisions between $A_2(g)$ and $B_2(g)$
C) increase the production of $B_2(g)$
D) increase the frequency of collisions between $A_2(g)$ and $B_2(g)$

17. A reaction is most likely to occur when reactant particles collide with

A) proper energy, only
B) proper orientation, only
C) both proper energy and proper orientation
D) neither proper energy nor proper orientation

18. Given the reaction:

$$A + B \rightarrow C + D$$

The reaction will most likely occur at the greatest rate if A and B represent

A) nonpolar molecular compounds in the solid phase
B) ionic compounds in the solid phase
C) solutions of nonpolar molecular compounds
D) solutions of ionic compounds

Rate of Reaction

19. Two reactant particles collide with proper orientation. The collision will be effective if the particles have

A) high activation energy
B) high ionization energy
C) sufficient kinetic energy
D) sufficient potential energy

20. Four aluminum samples are each reacted with separate 1 M copper sulfate solutions under the same conditions of temperature and pressure. Which aluminum sample would react most rapidly?

A) 1 gram bar of Al
B) 1 gram of Al ribbon
C) 1 gram of Al pellets
D) 1 gram of Al powder

21. Charcoal reacts with oxygen according to the equation

$$C(s) + O_2(g) \rightarrow CO_2(g).$$

Which of the following changes would cause the greatest increase in the rate of reaction?

A) decreasing the concentration of $O_2(g)$
B) decreasing the pressure of $O_2(g)$
C) using charcoal in powdered form
D) using charcoal in lump form

22. Which conditions will increase the rate of a chemical reaction?

A) decreased temperature and decreased concentration of reactants
B) decreased temperature and increased concentration of reactants
C) increased temperature and decreased concentration of reactants
D) increased temperature and increased concentration of reactants

23. As the temperature of a chemical reaction in the gas phase is increased, the rate of the reaction increases because

A) fewer particle collisions occur
B) more effective particle collisions occur
C) the required activation energy increases
D) the concentration of the reactants increases

24. The activation energy of a chemical reaction can be *decreased* by the addition of

A) a catalyst
B) an indicator
C) electrical energy
D) thermal energy

25. Given the reaction:

$$Mg + 2\ H_2O \rightarrow Mg(OH)_2 + H_2$$

At which temperature will the reaction occur at the greatest rate?

A) 25°C
B) 50°C
C) 75°C
D) 100°C

26. A 1-cubic-centimeter cube of sodium reacts more rapidly in water at 25°C than does a 1-cubic-centimeter cube of calcium at 25°C. This difference in rate of reaction is most closely associated with the different

A) surface area of the metal cubes
B) nature of the metals
C) density of the metals
D) concentration of the metals

27. A catalyst lowers the activation energy of a reaction by

A) providing an alternate reaction pathway
B) decreasing the heat of reaction
C) increasing the mass of the reactants
D) changing the mole ratio of the reactants

28. Adding a catalyst to a chemical reaction results in

A) a decrease in activation energy and a decrease in the reaction rate
B) a decrease in activation energy and an increase in the reaction rate
C) an increase in activation energy and a decrease in the reaction rate
D) an increase in activation energy and an increase in the reaction rate

29. A 5.0-gram sample of zinc and a 50.-milliliter sample of hydrochloric acid are used in a chemical reaction. Which combination of these samples has the fastest reaction rate?

A) a zinc strip and 1.0 M HCl(aq)
B) a zinc strip and 3.0 M HCl(aq)
C) zinc powder and 1.0 M HCl(aq)
D) zinc powder and 3.0 M HCl(aq)

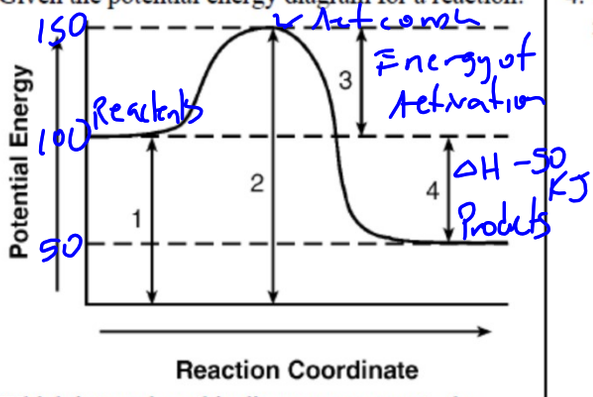
Regents Chemistry Name _____
Table I Worksheet

	Reaction	ΔH (kJ)	Endothermic or Exothermic
(1)	$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(\ell)$	−890.4	Exo
(2)	$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$	−483.6	Exo
(3)	$C_2H_5OH(\ell) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(\ell)$	−1367	Exo
(4)	$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(\ell)$	−2219.2	Exo
(5)	$4H_2O(\ell) + 3CO_2(g) \rightarrow C_3H_8(g) + 5O_2(g)$	+2219.2	Endo
	$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$	−91.8	Exo
	$CO_2(g) \rightarrow C(s) + O_2(g)$	+393.5	Endo
	$NH_4Cl(s) \rightarrow NH_4^+(aq) + Cl^-(aq)$	+14.78	Endo
	$2CO_2(g) + 4H_2O(\ell) \rightarrow 2CH_3OH(\ell) + 3O_2(g)$	+1452	Endo
	$2Al_2O_3(s) \rightarrow 4Al(s) + 3O_2(g)$	+3351	Endo
	$*CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$	−283	Exo
	$*4NO(g) \rightarrow 2N_2(g) + 2O_2(g)$	−365.2	Exo

1. If you reverse a reaction, what happens to the magnitude of ΔH? What happens to the sign?
   a. nothing happens to the value of ΔH
   b. the sign gets reversed, or flipped
2. If you double the concentration of the reactants and the products, what happens to the magnitude of ΔH? What happens to the sign?
   a. the value of ΔH also doubles
   b. nothing happens to the sign
3. If the ΔH for a given forward reaction is positive, will the reverse reaction be endothermic or exothermic?
   the reverse reaction will be exothermic
4. If a given reaction is exothermic, will heat be found on the reactants side of the equation or the products side?
   heat will be found on the products side of the equation
5. If a given reaction is endothermic, what will be the sign for ΔH for the reverse reaction?
   the sign for the reverse rxn will be negative

Regents Chemistry **PE Diagrams**

1. Given the potential energy diagram for a reaction:



Which interval on this diagram represents the difference between the potential energy of the products and the potential energy of the reactants?

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

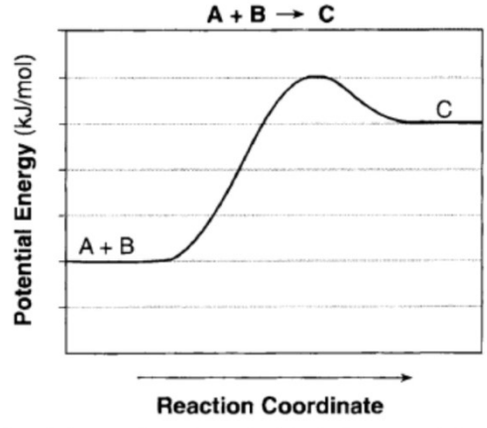
2. Which information about a chemical reaction is provided by a potential energy diagram?

A) the oxidation states of the reactants and products
B) the average kinetic energy of the reactants and products
C) the change in solubility of the reacting substances
D) the energy released or absorbed during the reaction

3. In a chemical reaction, the difference between the potential energy of the products and the potential energy of the reactants is equal to the

A) activation energy
B) entropy of the system
C) heat of fusion
D) heat of reaction

4. Given the equation and potential energy diagram representing a reaction:



If each interval on the axis labeled "Potential Energy (kJ/mol)" represents 10. kJ/mol, what is the heat of reaction?

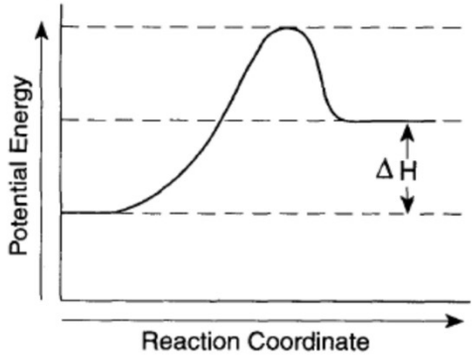
A) +60. kJ/mol B) +20. kJ/mol
C) +30. kJ/mol D) +40. kJ/mol

5. The activation energy required for a chemical reaction can be *decreased* by

A) increasing the surface area of the reactant
B) increasing the temperature of the reactant
C) adding a catalyst to the reaction
D) adding more reactant

PE Diagrams

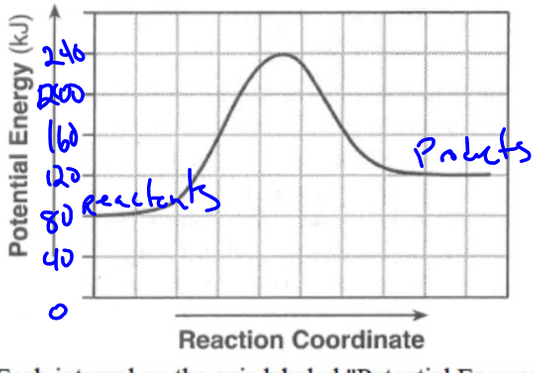
6. The diagram below represents the energy changes that occur during the formation of a certain compound under standard conditions.



According to Reference Table I, the compound could be

A) $C_2H_6(g)$ B) $CO_2(g)$
C) HI(g) D) $NH_3(g)$

7. The potential energy diagram for a chemical reaction is shown below.



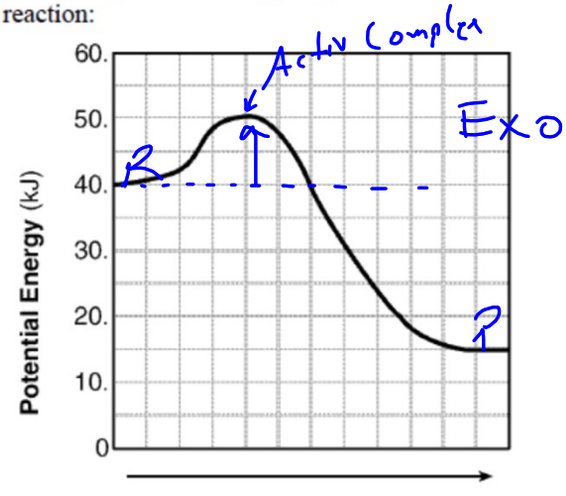
Each interval on the axis labeled "Potential Energy (kJ)" represents 40 kilojoules. What is the heat of reaction?

A) –120kJ B) –40kJ
C) +40kJ D) +160kJ

8. Changes in activation energy during a chemical reaction are represented by a

A) cooling curve
B) heating curve
C) ionization energy diagram
D) potential energy diagram

9. Given the potential energy diagram for a chemical reaction:



Which statement correctly describes the energy changes that occur in the forward reaction?

A) The activation energy is 10. kJ and the reaction is endothermic.
B) The activation energy is 10. kJ and the reaction is exothermic.
C) The activation energy is 50. kJ and the reaction is endothermic.
D) The activation energy is 50. kJ and the reaction is exothermic.

Regents Chemistry **Chemical Equilibrium**

1. Which statement must be true for any chemical reaction at equilibrium?

   A) The concentration of the products is less than the concentration of the reactants.
   B) The concentration of the products and the concentration of the reactants are equal.
   C) The concentration of the products and the concentration of the reactants are constant.
   D) The concentration of the products is greater than the concentration of the reactants.

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

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

3. Which factors must be equal in a reversible chemical reaction at equilibrium?

   A) the concentrations of the reactants and products
   B) the potential energies of the reactants and products
   C) the rates of the forward and reverse reactions
   D) the activation energies of the forward and reverse reactions

4. Given the reaction at equilibrium:

   $H_2(g) + Br_2(g) \leftrightarrow 2\ HBr(g)$

   The rate of the forward reaction is

   A) independent of the rate of the reverse reaction
   B) greater than the rate of the reverse reaction
   C) equal to the rate of the reverse reaction
   D) less than the rate of the reverse reaction

5. Which type or types of change, if any, can reach equilibrium?

   A) a chemical change, only
   B) both a chemical and a physical change
   C) neither a chemical nor a physical change
   D) a physical change, only

6. A chemical reaction has reached equilibrium when

   A) the reverse reaction begins
   B) the forward reaction ceases
   C) the concentrations of the reactants and products become equal
   D) the concentrations of the reactants and products become constant

7. Given the system at chemical equilibrium:

   $2\ O_3(g) \leftrightarrow 3\ O_2(g)$

   The concentration of O_3 and O_2 must be

   A) constant B) equal
   C) increasing D) decreasing

8. Given the reaction at equilibrium:

   $2\ CO(g) + O_2(g) \leftrightarrow 2\ CO_2(g)$

   Which statement regarding this reaction is always true?

   A) The rates of the forward and reverse reactions are equal.
   B) The concentrations of the reactants and the products are equal.
   C) The masses of the reactants and the products are equal.
   D) The reaction occurs in an open system.

9. Given the equation representing a system at equilibrium:

   $2SO_2(g) + O_2(g) \leftrightarrow 2SO_3(g)$

   At equilibrium, the concentration of

   A) $SO_2(g)$ must equal the concentration of $SO_3(g)$
   B) $SO_2(g)$ must be constant
   C) $O_2(g)$ must equal the concentration of $SO_2(g)$
   D) $O_2(g)$ must be decreasing

Le Chatelier's Principle

Le Chatelier's Principle says that when a system at equilibrium is subjected to a stress, the system will shift its equilibrium in order to relieve the stress. Additionally, all the species inside the reaction either increase or decrease in concentration.

Complete the following charts by writing left (←), right (→), or no shift (N/A) for the equilibrium shift that takes place in each column. For the concentration columns (the ones with brackets) write decreases (-), increases (+), or remains the same (0).

Remember that [ ] = concentration or amount of substance (the brackets will be seen surrounding that particular substance.

CHART #1:

4 2

$N_{2(g)} + 3H_{2(g)} \leftrightarrows 2NH_3(g) + 22.0\ kcal$

Stress	Equilibrium Shift	[N2]	[H2]	[NH3]
1. Add N2	→		dec	Inc
2. Add H2	→	dec		inc
3. Add NH3	←	inc	inc	
4. Remove N2	←		Inc	dec
5. Remove H2	←	inc		dec
6. Remove NH3	→	dec	dec	
7. Increase temperature	←	inc	inc	dec
8. Decrease temperature	→	dec	dec	inc
9. Increase pressure	→	dec	dec	inc
10. Decrease pressure	←	inc	inc	dec

OVER →

CHART #2:

2mol 2mol

$12.6\ kcal + H_{2(g)} + I_{2(g)} \leftrightarrows 2HI_{(g)}$

Stress	Equilibrium Shift	[H2]	[I2]	[HI]
1. Add H2	→		dec	inc
2. Add I2	→	dec		inc
3. Add HI	←	inc	inc	
4. Remove H2	←		inc	dec
5. Remove I2	←	inc		dec
6. Remove HI	→	dec	dec	
7. Increase temperature	→	dec	dec	inc
8. Decrease temperature	←	inc	inc	dec
9. Increase pressure	No shift	no change	no change	no change
10. Decrease pressure	No shift	no change	no change	no change

CHART #3:

$NaOH_{(s)} \leftrightarrows Na^{+}_{(aq)} + OH^{-}_{(aq)} + 10.6\ kcal$

** Remember that pure liquids and solids do not affect equilibrium values!

Stress	Equilibrium Shift	Amount $NaOH_{(s)}$	$[Na^+]$	$[OH^-]$
1. Add $NaOH_{(s)}$	No shift		no change	nochange
2. Add NaCl (Adds Na^+)	←	inc		dec
3. Add KOH (Adds OH^-)	←	inc	dec	
4. Add H^+ (Removes OH^-)	→	dec	inc	
5. Increase temperature	←	inc	dec	dec
6. Decrease temperature	→	dec	inc	inc
7. Increase Pressure	No shift	no change	no change	no change
8. Decrease pressure	No shift	no change	no change	no change

Regents Chemistry **LeChatelier's Principle**

1. In which reaction will the point of equilibrium shift to the left when the pressure on the system is increased?

A) $CaCO_3(s) \leftrightarrow CaO(s) + CO_2(g)$
B) $2\ Mg(s) + O_2(g) \leftrightarrow 2\ MgO(s)$
C) $2\ H_2(g) + O_2(g) \leftrightarrow 2\ H_2O(g)$
D) $C(s) + O_2(g) \leftrightarrow CO_2(g)$

2. Given the system at equilibrium:

$N_2O_4(g) + 58.1\ kJ \leftrightarrow 2\ NO_2(g)$

What will be the result of an increase in temperature at constant pressure?

A) The equilibrium will shift to the right, and the concentration of $NO_2(g)$ will decrease.
B) The equilibrium will shift to the left, and the concentration of $NO_2(g)$ will decrease.
C) The equilibrium will shift to the right, and the concentration of $NO_2(g)$ will increase.
D) The equilibrium will shift to the left, and the concentration of $NO_2(g)$ will increase.

3. Given the reaction at equilibrium:

$C_2(g) + D_2(g) \leftrightarrow 2\ CD(g) + energy$

Which change will cause the equilibrium to shift?

A) addition of a catalyst
B) increase in volume
C) increase in pressure
D) addition of heat

4. Given the reaction at equilibrium:

$2\ SO_2(g) + O_2(g) \leftrightarrow 2\ SO_3(g)$

As the pressure is increased at constant temperature, the number of moles of $SO_3(g)$ produced will

A) decrease
B) increase
C) remain the same

5. Given the reaction at equilibrium:

$N_2(g) + 3\ H_2(g) \leftrightarrow 2\ NH_3(g)$

Increasing the concentration of $N_2(g)$ will increase the forward reaction rate due to

A) a decrease in the activation energy
B) a decrease in the number of effective collisions
C) an increase in the activation energy
D) an increase in the number of effective collisions

6. Given the reaction at equilibrium:

$C(s) + CO_2(g) + heat \leftrightarrow 2CO(g)$

Which stress on the system would favor the production of $CO(g)$?

A) an increase in the pressure
B) an increase in the temperature
C) a decrease in the amount of $C(s)$
D) a decrease in the amount of $CO_2(g)$

7. Given the system at equilibrium:

$H_2(g) + F_2(g) \leftrightarrow 2\ HF(g) + heat$

Which change will *not* shift the point of equilibrium?

A) changing the concentration of $H_2(g)$
B) changing the temperature
C) changing the pressure
D) changing the concentration of $HF(g)$

8. Given the closed system at equilibrium:

$CO_2(g) \leftrightarrow CO_2(aq)$

As the pressure on the system increases, the solubility of the $CO_2(g)$

A) decreases
B) increases
C) remains the same

LeChatelier's Principle

9. Given the reaction at equilibrium:

$$2\ CO(g)\ +\ O_2(g) \leftrightarrow\ 2\ CO_2(g)$$

When the reaction is subjected to stress, a change will occur in the concentration of

A) reactants, only
B) products, only
C) both reactants and products
D) neither reactants nor products

10. Given the reaction at equilibrium:

$$H_2(g) + Cl_2(g) \leftrightarrow 2\ HCl(g)$$

As the pressure increases at constant temperature, the number of moles of HCl

A) decreases B) increases
C) remains the same

11. Given the equation representing a reaction at equilibrium:

$$N_2(g) + 3\ H_2(g) \rightleftharpoons 2\ NH_3(g) + \text{energy}$$

Which change causes the equilibrium to shift to the right?

A) decreasing the pressure
B) decreasing the concentration of $H_2(g)$
C) increasing the temperature
D) increasing the concentration of $N_2(g)$

12. What occurs when the temperature is increased in a system at equilibrium at constant pressure?

A) The rate of the forward reaction increases, and the rate of the reverse reaction decreases.
B) The rate of the forward reaction decreases, and the rate of the reverse reaction increases.
C) The rate of the exothermic reaction decreases.
D) The rate of the endothermic reaction increases.

13. Given the reaction at equilibrium:

$$2\ SO_2(g) + O_2(g) \leftrightarrow 2\ SO_3(g) + \text{heat}$$

Which change will shift the equilibrium to the right?

A) decreasing the amount of $SO_2(g)$
B) decreasing the amount of $O_2(g)$
C) increasing the pressure
D) increasing the temperature

14. Given the equation representing a system at equilibrium:

$$N_2(g) + 3H_2(g) \leftrightarrow 2NH_3(g) + \text{energy}$$

Which changes occur when the temperature of this system is *decreased*?

A) The concentration of $H_2(g)$ decreases and the concentration of $NH_3(g)$ decreases.
B) The concentration of $H_2(g)$ decreases and the concentration of $N_2(g)$ increases.
C) The concentration of $H_2(g)$ increases and the concentration of $N_2(g)$ increases.
D) The concentration of $H_2(g)$ decreases and the concentration of $NH_3(g)$ increases.

15. Given the equation representing a reaction at equilibrium:

$$N_2(g) + 3H_2(g) \leftrightarrow 2NH_3(g)$$

What occurs when the concentration of $H_2(g)$ is increased?

A) The equilibrium shifts to the left, and the concentration of $N_2(g)$ decreases.
B) The equilibrium shifts to the left, and the concentration of $N_2(g)$ increases.
C) The equilibrium shifts to the right, and the concentration of $N_2(g)$ decreases.
D) The equilibrium shifts to the right, and the concentration of $N_2(g)$ increases

ENTROPY

Name _____

Determine whether the following reactions show an increase or decrease in entropy and specify the phase change or change in # of moles.

1. $2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$ — inc (s) → (g)
2. $H_2O(\ell) \rightarrow H_2O(s)$ — dec (ℓ) → (s)
3. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ (4 mol → 2 mol) — dec 4 mol → 2 mol
4. $NaCl(s) \rightarrow Na^+(aq) + Cl^-(aq)$ — inc (s) → (aq)
5. $KCl(s) \rightarrow KCl(\ell)$ — inc (s) → (ℓ)
6. $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(\ell)$ — dec (g) → (ℓ)
7. $CO_2(s) \rightarrow CO_2(g)$ — inc (s) → (g)
8. $H^+(aq) + C_2H_3O_2^-(aq) \rightarrow HC_2H_3O_2(\ell)$ — dec (aq) → (l)
9. $C(s) + O_2(g) \rightarrow CO_2(g)$ — inc (s) → (g)
10. $2CH_3OH(\ell) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(\ell)$ (3 → 2) — dec 3 mol (g) → 2 mol (g)
11. $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$ — none, no change in phase or # mols
12. $Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$ — dec (aq) → (s)
13. $2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$ (2 mol → 5 mol) — inc 2 mol → 5 mol
14. $2Al(s) + 3I_2(s) \rightarrow 2AlI_3(s)$ (5 mol → 2 mol) — dec 5 mol → 2 mol
15. $C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(\ell)$ — inc (s) → (ℓ)
16. $H^+(aq) + OH^-(aq) \rightarrow H_2O(\ell)$ — dec (aq) → (l)
17. $2NO(g) \rightarrow N_2(g) + O_2(g)$ — none, no change in phase or # mol
18. $H_2O(g) \rightarrow H_2O(\ell)$ — dec (g) → (ℓ)
19. $4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$ — dec (g) → (s)
20. $2C_8H_{18}(\ell) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(\ell)$ (25 → 16) — dec 25 mol (g) → 16 mol (g)

Enthalpy and Table I

Look in your Reference Tables (Table I) and state whether the following reactions are exothermic or endothermic.

	Exo or Endo
1. Methane (CH_4) combining with oxygen to produce carbon dioxide and water	Exo
2. Potassium nitrate dissociating into a positive potassium ion and a negative nitrate ion	Endo
3. Sodium hydroxide dissociating into a positive sodium ion and a negative hydroxide ion	Exo
4. Carbon monoxide combining with oxygen to form carbon dioxide	Exo
5. **A positive lithium ion combining with a negative bromine ion to form lithium bromide	Endo

Process	ΔH	Exo or Endo	Entropy change
1. $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)}$	-571.6	Exo	↓
2. $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$	-393.5	Exo	↑
3. $CO_{2(g)} \rightarrow C_{(s)} + O_{2(g)}$	+393.5	Endo	↓
4. $2C_{(s)} + H_{2(g)} \rightarrow C_2H_{2(g)}$	+227.4	Endo	↑
5. $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)}$	-483.6	Exo	↓
6. $C_6H_{12}O_{6(s)} + 6O_{2(g)} \rightarrow 6CO_{2(g)} + 6H_2O_{(l)}$	-2804	Exo	↑
7. $Br^-_{(aq)} + Li^+_{(aq)} \rightarrow LiBr_{(s)}$	+48.83	Endo	↓
8. $H_{2(g)} + I_{2(g)} \rightarrow 2HI_{(g)}$	+53.0	Endo	none
9. $NaOH_{(s)} \rightarrow Na^+_{(aq)} + OH^-_{(aq)}$	-44.51	Exo	↑
10. $2CO_{2(g)} \rightarrow O_{2(g)} + 2CO_{(g)}$	+566.0	Endo	↑