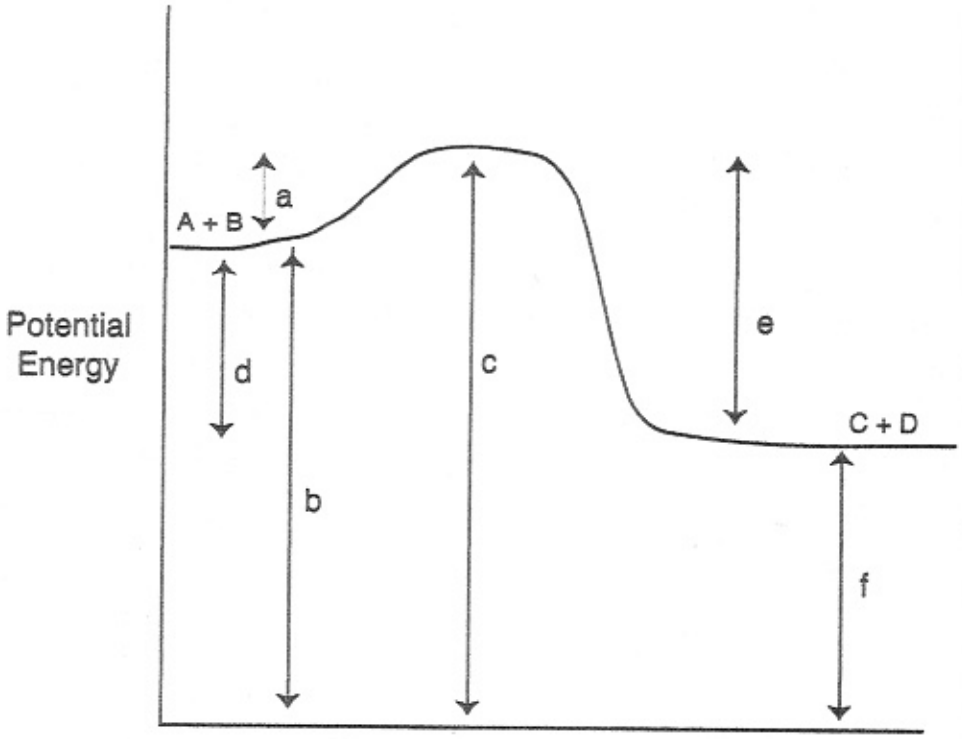
– Answer Keys –

POTENTIAL ENERGY DIAGRAM

Name 5/4

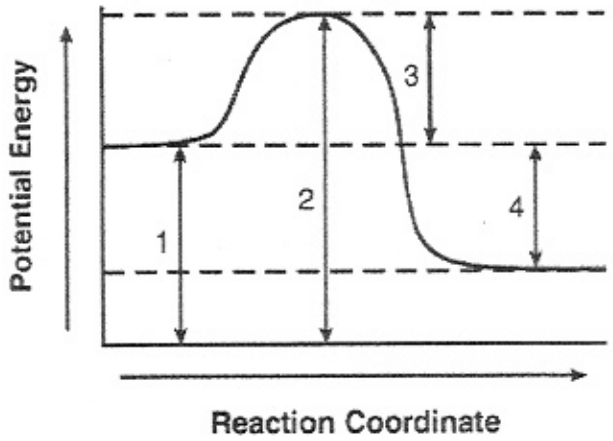


A + B ↔ C + D + energy

Answer the questions using the graph above.

1. Is the above reaction endothermic or exothermic? exothermic
2. What letter represents the potential energy of the reactants? b
3. What letter represents the potential energy of the products? f
4. What letter represents the heat of reaction (ΔH)? d
5. What letter represents the activation energy of the forward reaction? a
6. What letter represents the activation energy of the reverse reaction? e
7. What letter represents the potential energy of the activated complex? c
8. Is the reverse reaction endothermic or exothermic? endothermic
9. If a catalyst were added, what letter(s) would change? a, c, e

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

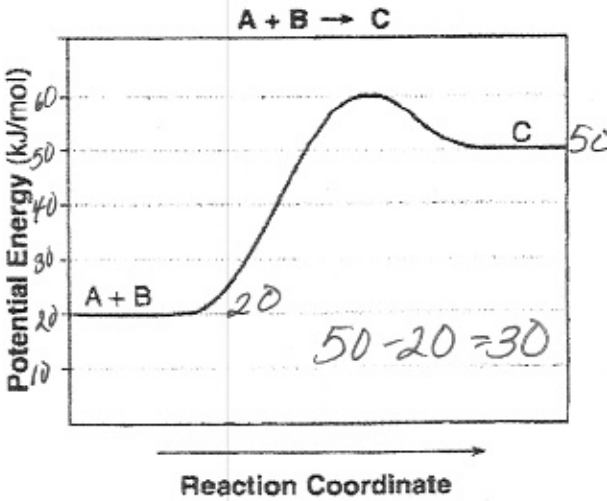
2. Which information about a chemical reaction is provided by a potential energy diagram?

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:



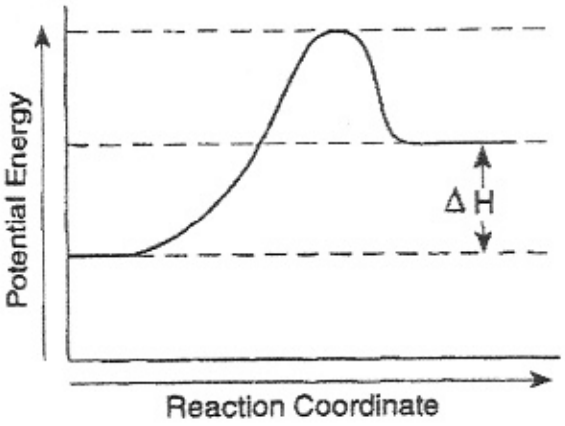
If each interval on the axis labeled "Potential Energy (kJ/mol)" represents 10. kJ/mol, what is th heat of reaction?

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

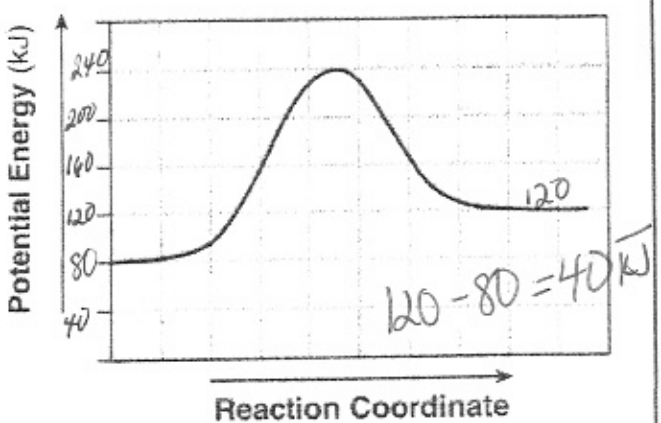
6. The diagram below represents the energy changes that occur during the formation of a certain compound under standard conditions.



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.



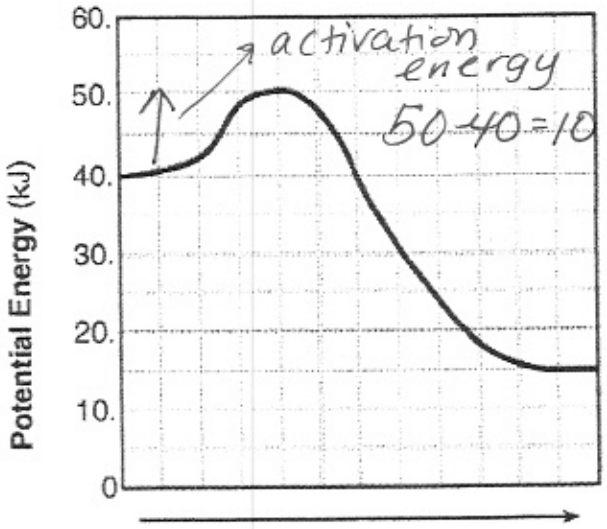
Each interval on the axis labeled "Potential Energy (kJ)" represents 40 kilojoules. What is the heat of reaction?

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

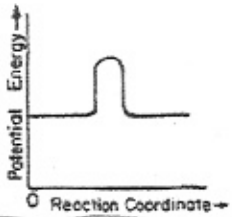
9. Given the potential energy diagram for a chemical reaction:

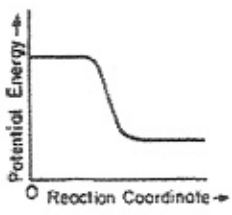


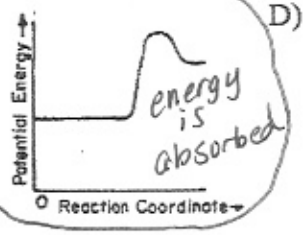
Which statement correctly describes the energy changes that occur in the forward reaction?

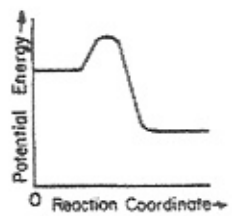
A) The activation energy is 10. kJ and the reaction is endothermic.
B) The activation energy is 10. kJ and the reaction is exothermic.
C) The activation energy is 50. kJ and the reaction is endothermic.
D) The activation energy is 50. kJ and the reaction is exothermic.

10. Which graph represents an endothermic reaction?

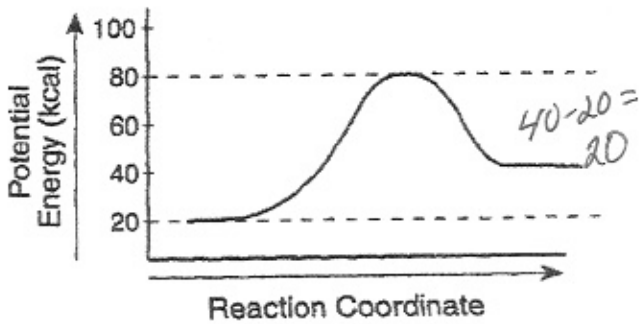
A)


B)


C)


D)


11. A potential energy diagram of a chemical reaction is shown below.



What is the difference between the potential energy of the reactants and the potential energy of the products?

A) 20. kcal B) 40. kcal
C) 60. kcal D) 80. kcal

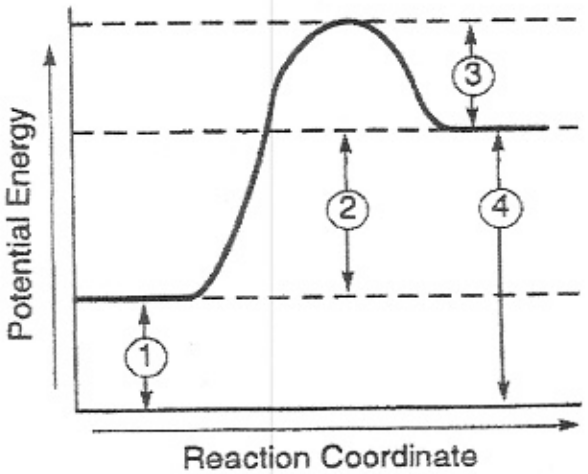
12. In a potential energy diagram, the difference between the potential energy of the products and the potential energy of the reaction is equal to the

A) heat of reaction
B) entropy of the reaction
C) activation energy of the forward reaction
D) activation energy of the reverse reaction

13. Given the reaction:

$N_2(g) + 2\,O_2(g) \leftrightarrow 2\,NO_2(g)$
$\Delta H = +7.9$ kcal/mole

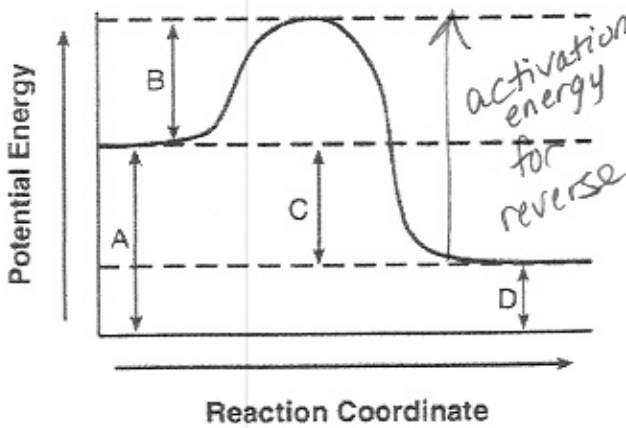
The potential energy diagram of the reaction is shown below.



Which arrow represents the heat of reaction (ΔH) for the reverse reaction?

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

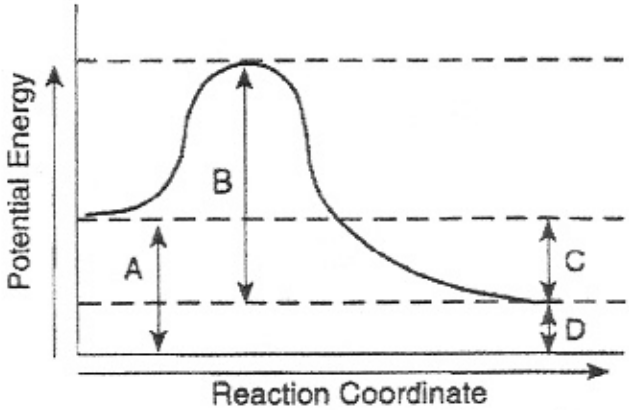
14. Given the potential energy diagram representing a reversible reaction:



The activation energy for the reverse reaction is represented by

A) $A + B$ B) $B + C$
C) $B + D$ D) $C + D$

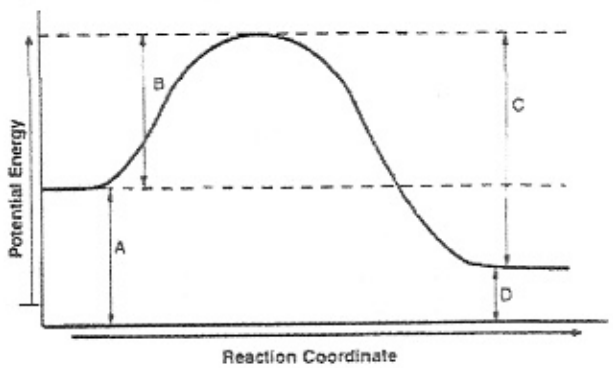
15. The potential energy diagram of a chemical reaction is shown below.



Which arrow represents the part of the reaction most likely to be affected by the addition of a catalyst?

A) *A* B) *B* C) *C* D) *D*

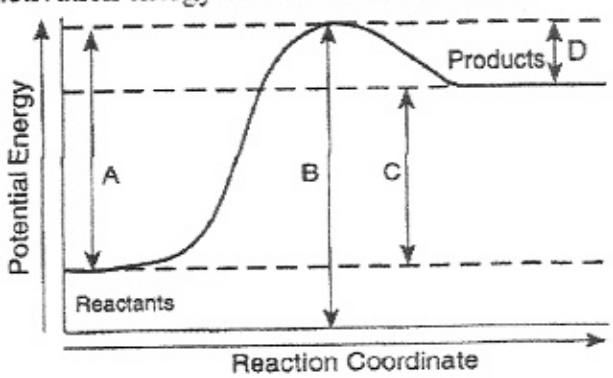
16. A potential energy diagram is shown below.



Which letters represent the activation energy of the forward and reverse reactions, respectively?

A) *A* and *C* B) *A* and *D*
C) *B* and *C* D) *B* and *D*

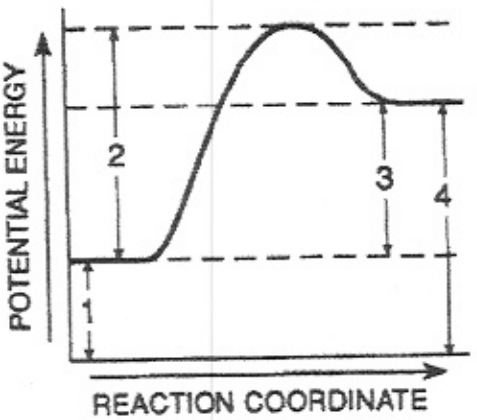
13. In the diagram below, which letter represents the activation energy for the reverse reaction?



A) *A* B) *B* C) *C* D) *D*

14. The potential energy diagram below represents the reaction

$2\ KClO_3 \rightarrow 2\ KCl + 3\ O_2$.



Which numbered interval on the diagram would change when a catalyst is added?

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

Le Chatelier's Principle 5/7

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:

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

Stress	Equilibrium Shift	[N2]	[H2]	[NH3]
1. Add N2 use it up	→	X	−	+
2. Add H2	→	−	X	+
3. Add NH3	←	+	+	X
4. Remove N2 make more	←	X	+	−
5. Remove H2	←	+	X	−
6. Remove NH3	→	−	−	X
7. Increase temperature	←	+	+	−
8. Decrease temperature	→	−	−	+
9. Increase pressure fewer moles	→	−	−	+
10. Decrease pressure greater moles	←	+	+	−

OVER →

LeChatelier's Principle

5/8

With hints ☺

1) In which reaction will the point of equilibrium shift to the left when the pressure on the system is increased? → all gases only!

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:

$N_2O_4(g) + 58.1\text{ kJ} \leftrightarrow 2\,NO_2(g)$

What will be the result of an increase in temperature at constant pressure? → go "away" from heat

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:

$C_2(g) + D_2(g) \leftrightarrow 2\,CD(g) + \text{energy}$

Which change will cause the equilibrium to shift?

A) addition of a catalyst
B) increase in volume
C) increase in pressure No! Same moles on both sides!
D) addition of heat

4) Given the reaction at equilibrium:

$2\,SO_2(g) + O_2(g) \leftrightarrow 2\,SO_3(g)$ Shifts right →

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

→ Increase pressure favors fewer moles!

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:

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

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

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 $CO_2(g)$

go "away" from heat to use it up

7) 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? Fewer moles on 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

8) 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.

(9) 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*? go toward heat/ produce heat

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.

(10) 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

CHART #2:

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

Whether forward or reverse reaction, reactants decrease & prod

Stress	Equilibrium Shift	[H2]	[I2]	[HI]
1. Add H2	→		(decrease)	(increase)
2. Add I2	→	−		+
3. Add HI	←	+	+	
4. Remove H2	←		+	−
5. Remove I2	←	+		−
6. Remove HI	→	−	−	
7. Increase temperature	→	−	−	+
8. Decrease temperature	←	+	+	−
9. Increase pressure (Fewer moles!)	none	same	same	same
10. Decrease pressure	none	same	same	same