1. Ice cubes (the system) in a glass of water melt and cool the surrounding water. Is energy exchanged by heat or work in this example, and is the sign of heat or work for the system positive or negative?

1. Energy is exchanged as work, and the sign for work is positive.
2. Energy is exchanged as work, and the sign for work is negative.
3. Energy is exchanged as heat, and the sign for heat is positive.
4. Energy is exchanged as heat, and the sign for heat is negative.
5. Energy is not exchanged in this scenario.

2. Substances A and B, initially at different temperatures, come in contact with each other and reach the same final temperature. The mass of substance A is twice the mass of substance B. The specific heat capacity of substance B is twice the specific heat capacity of substance A.

Which statement is true about the final temperature of the two substances?

1. The final temperature is closer to the initial temperature of substance A than substance B.
2. The final temperature is closer to the initial temperature of substance B than substance A.
3. The final temperature is exactly midway between the initial temperatures of substances A and B.
4. The final temperature is the initial temperature of substance A.
5. The final temperature is the initial temperature of substance B.

3. When 0.00438 moles of C12H22O11 undergo combustion in a bomb calorimeter, the temperature rises from 25.25 oC to 28.93 oC. The heat capacity of the bomb calorimeter was determined in a separate experiment to be 4.95 kJ/oC. What is the heat of reaction for the combustion of C12H22O11 in kJ/mol?

1. 12.1 kJ/mol
2. 18.2 kJ/mol
3. 27.3 kJ/mol
4. 60.1 kJ/mol
5. 4.16x103 kJ/mol

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 4. Calculate the standard reaction enthalpy for the oxidation of nitric oxide to nitrogen dioxide, 2NO(g) + O2(g)  2NO2(g), using the standard reaction enthalpies below:   |  |  |  | | --- | --- | --- | |  | N2(g) + O2(g)  2NO(g) | H° = +180.5 kJ/mol | | |  |  | | --- | --- | |  |  | | 2NO2(g)  N2(g) + 2O2(g) | H° = 66.4 kJ/mol | | | |
| 1. 114.1 kJ/mol |
| 1. 246.9 kJ/mol |
| 1. 114.1 kJ/mol |
| 1. 294.6 kJ/mol |
| 1. 246.9 kJ/mol |

5. Which statement is true regarding internal energy, enthalpy, heat and work?

1. At constant volume, change in internal energy is equal to work.
2. At constant pressure, change in internal energy is equal to heat.
3. At constant volume, change in **enthalpy** is equal to work.
4. At constant pressure, change in **enthalpy** is equal to heat.
5. At constant volume and pressure, change in internal **energy** is equal to change in enthalpy.

6. Use the heating curve for a 1.00 mole sample of isopropyl alcohol (C3H8O) to determine how much heat (in kJ) is required to transform 2.00 moles of liquid C3H8O at 355.5 K to gaseous C3H8O at 355.5 K. *Note that the graph is not to scale and the isopropyl alcohol is completely in the liquid state at point C in the diagram below*.



1. 15.5 kJ
2. 27.5 kJ
3. 45.0 kJ
4. 55.0 kJ
5. 91.0 kJ

7. The standard enthalpy of formation for gaseous methanol, CH3OH(g), is -201 kJ. Which statement is true?

1. The reactants in the chemical reaction that represents the standard enthalpy of formation include H2O(g) and C(s).
2. When 1.00 mol of CH3OH is formed, 201 kJ of heat energy is absorbed.
3. A total of 603 kJ of heat energy is released when 3 moles of CH3OH forms.
4. The chemical reaction that represents the standard enthalpy of formation is 2C(s) + 4 H2(g) + O2(g) 🡪 2 CH3OH(g) + 201 kJ
5. The standard enthalpy of formation for CH3OH(l) represents and endothermic reaction.

8. Which answer correctly identifies the relative standard molar entropies for the substances?

1. Br2(g) > F2(g)
2. NaNO3(s) > NaNO3(aq)
3. H2O(l) > H2O(g)
4. I2(l) > I2(g)
5. CH4(g) > C2H6(g)

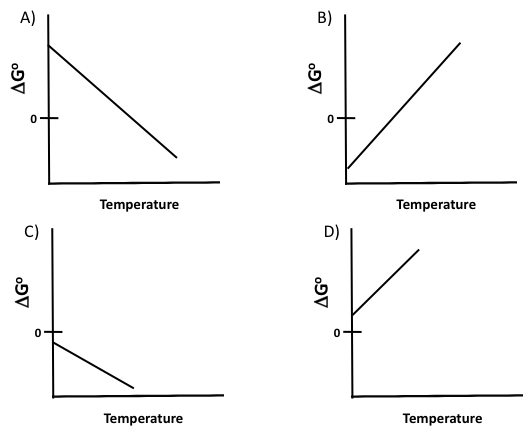
9. Which statement regarding entropy is true?

1. An increase in entropy represents an increase in the order of the system.
2. An increase in the temperature of the surroundings must be exactly offset by a decrease in entropy of the system.
3. It is not possible for the entropy of a system to decrease (per the second law of thermodynamics).
4. A system with more microstates has greater entropy.
5. Both statements B and D are true.

10. Which statement *must be* true regarding Gibbs free energy?

1. The change in Gibbs free energy of the system is directly relatable to entropy change of the universe at constant temperature and pressure.
2. The change in Gibbs free energy for an exothermic system is negative.
3. Gibbs free energy is *not* a state function.
4. An increase in Gibbs free energy for a chemical reaction indicates that the reaction is spontaneous under that specific set of conditions.
5. A decrease in Gibbs free energy for a chemical reaction or process indicates that the reaction or process occurs quickly.

11. For a given reaction at 45.0 oC, Ho = +293 kJ and So = +69.5 J/K. Which graph correlates to this reaction?



E) None of these

12. Dinitrogen pentoxide, N2O5, decomposes according to the chemical equation below. Which statement is true if the rate of decomposition of N2O5 is

4.0 x 10-6 M/s?

2N2O5(g) 🡪 4NO2(g) + O2(g)

1. The rate of production of NO2 is equal to the rate of production of O2.
2. The rate of production of NO2 is four times the rate of decomposition of N2O5.
3. The rate of production of NO2 is faster than the rate of decomposition of N2O5 while the rate of production of O2 is slower than that of N2O5 decomposition.
4. The rate of production of O2 is 8.0 x 10-6 M/s
5. The rate of production of NO2 is 2.0 x 10-6 M/s

13. The reaction of CO(g) and NO2(g) is first-order in NO2 and second-order in CO. How will the reaction rate change if the concentration of NO2 is halved while the concentration of CO is doubled?

A) The rate will not change.

B) The rate will decrease to ¼ the original rate.

C) The rate will decrease to ½ the original rate.

D) The rate will double.

E) The rate will increase by a factor of 4.

14. The first order rate constant for the decomposition of N**2**O**5**(g) at 70°C is

0.409 min**-1**.

2N**2**O**5**(g) → 4NO**2**(g) + O**2**(g)

If you start with 0.0125 M N**2**O**5**(g), how many minutes will it take for the concentration of of N**2**O**5**(g) to drop to 0.0050 M?

A) 150 min.

B) 9.0 min.

C) 2.2 min.

D) 0.018 min.

E) 290 min.

15. Consider the following equation:

2 NO2(g) + F2(g) → NO2F(g)

The initial rate of reaction is measured at several different concentrations of the reactants with the following results:

|  |  |  |
| --- | --- | --- |
| **[NO2] (*M*)** | **[F2] (*M*)** | **Initial Rate (*M*/s)** |
| 0.100 | 0.100 | 0.026 |
| 0.200 | 0.100 | 0.051 |
| 0.200 | 0.200 | 0.102 |
| 0.400 | 0.400 | 0.411 |

From the data above, determine the rate law for the reaction, with rate constant, k.

A) Rate = *k* [NO2][F2]

B) Rate = *k* [NO2]

C) Rate = *k* [F2]

D) Rate = *k* [NO2]**2**[F2]

E) Rate = *k* [NO2][F2] **2**

16. The plot of ln *k* vs. 1/T for a given reaction is linear and can be described by the equation *y* = -(11200)*x* + 26.8. What is the activation energy (in kJ/mol) for this reaction?

1. 11.2 kJ/mol
2. 26.8 kJ/mol
3. 93.1 kJ/mol
4. 223 kJ/mol
5. 919 kJ/mol

17. Considering the diagram below, which statement best describes the overall reaction from A to D?



1. This reaction will not proceed because B and C are higher energy than A.
2. The rate expression will depend on concentrations of A, B, and C.
3. The transformation from C to D is fastest so it will dominate the reaction rate.
4. Species A is the only concentration that will appear in the overall rate expression.
5. All of B must be completely converted to C before any product D is made.

18. Consider the two-step mechanism for a reaction below and determine which statement is true.



A) The reaction has a catalyst

B) ClNO2(g) is an intermediate.

C) The overall rate law is: rate = k[NO2]2[Cl2]

D) The overall reaction is first order in NO2.

E) The rate constant for the overall reaction is k2.

19. Which statement is true regarding the reaction mechanism that accompanies the graph in Question 17?

A) A, B, C, and D are reactants, and E is a product.

B) The overall reaction is A + B + C 🡪 D

C) B and C represent transition states.

D) E represents an intermediate.

E) The reaction mechanism has three steps.

20. Which phrase or statement best characterizes activation energy?

1. The difference in energy of the products and reactants in an overall reaction
2. The energy at the highest point on a reaction progress diagram minus the energy of the reactants.
3. The difference in the amount of energy required for breaking bonds in the reactants and forming bonds in the products.
4. The energy released during the reaction.
5. The energy required for a reaction to be spontaneous.

21. Which form of the exam do you have?

A) B)