Name _________________________________ Date _________________ Period _____

Thermodynamics Review

Matching:

_____ 1. The ability to do work or produce heat.
_____ 2. States that energy cannot be created or destroyed.
_____ 3. Energy flowing from a warmer to a cooler object.
_____ 4. Energy stored in a substance because of its composition.
_____ 5. Heat required to raise the temperature of one gram of a substance by one degree Celsius.
_____ 6. An insulated device measuring the heat absorbed or released during a chemical or physical process.
_____ 7. The system plus the surroundings.
_____ 8. States that spontaneous processes always proceed in such a way that the entropy of the universe increase.
_____ 9. A physical or chemical change without outside intervention.
_____ 10. Energy that is available to do work.

a. calorimeter
b. law of disorder
c. chemical potential energy
d. heat
e. free energy
f. law of conservation of energy
g. specific heat
h. energy
i. universe
j. spontaneous process

Short Answer:

11. How does the nutritional Calorie compare with the calorie?

12. The enthalpy change for a reaction is negative. What does this indicate about the chemical potential energy of the system before and after the reaction?

13. How many joules of heat are lost by 3580 kg granite as it cools from 41.2°C to -12.0°C? (the specific heat of granite = 0.803 J/g-°C)

14. How much heat is absorbed by 2000 kg granite boulder as energy from the sun causes its temperature to change from 10°C to 29°C?

15. A sample of silver with a mass of 63.3 g is heated to a temperature of 384.4 K and placed in a container of water at 290.0 K. The final temperature of the silver and water is 292.4 K. Assuming no heat loss, what mass of water was in the container? The specific heat of water is 4.184 J/g-°C and silver 0.24 J/g-°C.

16. A swimming pool 20.0 m x 12.5 m is filled with water to a depth of 3.75 m. If the initial temperature of the water is 18.4 °C, how much heat must be added to the water to raise its temperature to 29.0 °C? Assume that the density of water 1.000 g/mL.

17. When hydrogen peroxide is placed on a cut knee it decomposes to form water and oxygen gas. What is the heat change when 34.0 g of H_2O_2 decomposes according to the following equation?

$2H_2O_2(l) \rightarrow 2H_2O(l) + O2(g) + 200kJ$

18. Manganese will react with hydrochloric acid to produce hydrogen gas according to the following equation: What is the heat change when 5.494 g of manganese reacts completely?

$Mn(s) + 2\ HCl(aq) \rightarrow MnCl_2(aq) + H_2(g) + 221\ kJ$

19. How many kilojoules of energy will be needed to decompose 10.8 grams of N_2O_5 gas?

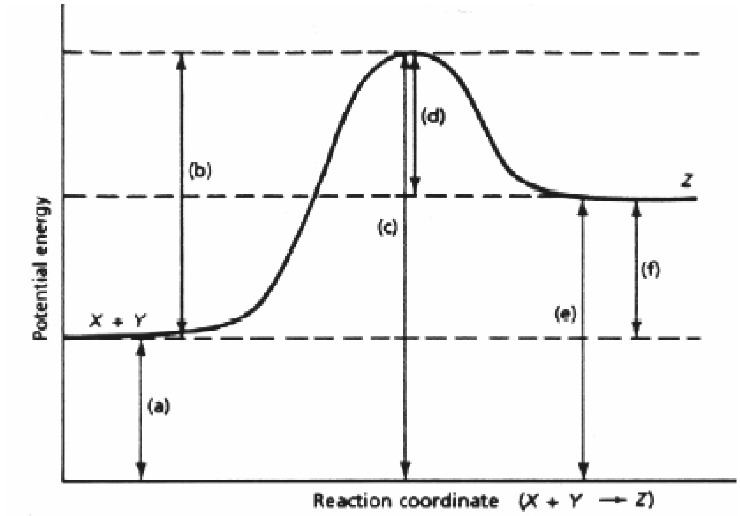
$2\ N_2O_5\ (g) + 110\ kJ \rightarrow 4NO_2(g) + O_2(g)$

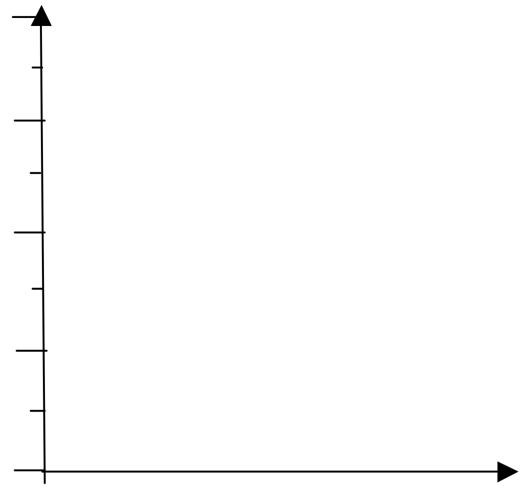
20. Phosphorous burns in air to produce dense white clouds of P_4O_{10} gas. When this gas is dissolved in rain water, phosphoric acid is produced. What is the heat change when 14.2 g of P_4O_{10} reacts?

$P_4O_{10}\ (g) + 6H_2O(l) \rightarrow 4\ H_3PO_4(aq) + 424\ kJ$

21. Methane (CH4) gas is used as a fuel for heating hot water in many of our homes. In addition it is the gas used to fuel the Bunsen burners in our lab. Write the thermochemical equation for the combustion of methane gas. The ΔH for methane is –890 kJ/mol. What is the heat change when 32.0 grams of methane burns?

22.





a. Which of the letters a–f in the first diagram represents the potential energy of the products? _______
b. Which letter indicates the potential energy of the reactants? ________
c. Which letter indicates the activation energy? _____
d. Which letter indicates the heat of reaction, ΔH? ______
e. Is the reaction exothermic or endothermic? ______
f. Would the reverse reaction be exothermic or endothermic? ___

To the right, complete the potential energy diagram for an exothermic reaction, where the reactants have 250kJ of potential energy stored in their chemical bonds, there is 100kJ of activation energy required and the products have 50kJ of potential energy stored in their chemical bonds. Scale and label the y axis for kJ of potential energy. Calculate ΔH = _____________ Also, show the effect to activation energy when a catalyst is added.

23. Complete the table for the sign of ΔG; +, - or undetermined. When conditions allow for an undetermined sign of ΔG, temperature will decide spontaneity.

ΔH	ΔS	ΔG
-	+	
+	-	
-	-	
+	+	

24. The vaporization of bromine requires 31.0 kJ/mol and an increase in disorder (ΔS° = 93.0 J/(mol•K)). At what temperature will this process be spontaneous?

$Br_2 (l) \rightarrow Br_2 (g)$

25. The entropy of a system at 337.1 K increases by 221.7 J/mol•K. The free energy value is found to be –717.5 kJ/mol. Calculate the change in enthalpy of this system.

26. Copper (I) sulfide reacts with sulfur to produce copper (II) sulfide under standard conditions. The process is exothermic ($\Delta H°$ = -26.7 kJ/mol) with a decrease in disorder ($\Delta S°$ = -19.7 J/(mol•K)). Determine the spontaneity of the reaction by calculating $\Delta G°$.

$$Cu_2S\ (s) + 2\ S\ (s) \rightarrow 2\ CuS\ (s)$$

27. The hydrogenation of ethene gas under standard conditions (T = 298.K) shows a decrease in disorder ($\Delta S°$ = -0.1207 kJ/(mol•K)) during an exothermic reaction ($\Delta H°$ = -136.9 kJ/mol). Determine whether the reaction is spontaneous or nonspontaneous by calculating $\Delta G°$.

$$C_2H_4\ (g) + H_2\ (g) \rightarrow C_2H_6\ (g)$$

28. A system at 776.5 K undergoes a change in enthalpy of –5.711 kJ/mol. If the free energy value is 6.771 kJ/mol, what is the change in entropy?

29. Calculate the standard enthalpy change, $\Delta H°$, for the formation of 1 mol of strontium carbonate (the material that gives the red color in fireworks) from its elements.

$$Sr\ (s) + C(graphite) + \tfrac{3}{2}\ O_2\ (g) \rightarrow SrCO_3\ (s)$$

The information available is

(1) $Sr\ (s) + \frac{1}{2}\ O_2\ (g) \rightarrow SrO\ (s)$ $\Delta H°$ = -592 kJ

(2) $SrO\ (s) + CO_2\ (g) \rightarrow SrCO_3\ (s)$ $\Delta H°$ = -234 kJ

(3) $C(graphite) + O_2\ (g) \rightarrow CO_2\ (g)$ $\Delta H°$ = -394 kJ

30. The combination of coke and steam produces a mixture called coal gas, which can be used as a fuel or as a starting material for other reactions. If we assume coke can be represented by graphite, the equation for the production of coal gas is

$$2\ C\ (s) + 2\ H_2O\ (g) \rightarrow CH_4\ (g) + CO_2(g)$$

Determine the standard enthalpy change for this reaction from the following standard enthalpies of reaction :

(1) $C(s) + H_2O\ (g) \rightarrow CO\ (g) + H_2\ (g)$ $\Delta H°$ = 131.3 kJ

(2) $CO\ (g) + H_2O\ (g) \rightarrow CO_2\ (g) + H_2\ (g)$ $\Delta H°$ = -41.2 kJ

(3) $CH_4\ (g) + H_2O\ (g) \rightarrow 3\ H_2\ (g) + CO\ (g)$ $\Delta H°$ = 206.1 kJ