Thermodynamics practice problems

KEY

1) How can energy be transferred to or from a system? 1) _____

A) Energy can only be transferred as potential energy, which is converted to kinetic energy.
B) Energy can be transferred only as heat.
C) Energy can be transferred only as work.
D) Energy can be transferred as heat and/or work.

2) Which of the following is an example of a state function? 2) _____

A) The length of time it takes to go from New York to Los Angeles
B) The mileage traveled going from San Francisco to Los Angeles
C) The amount of work required to travel from New Orleans to St. Louis
D) The amount of time it takes to change the channel when *Gossip Girl* comes on.
E) The difference in altitude between Chicago and Denver

3) Which of the following is NOT a state property? 3) _____

A) pressure
B) internal energy
C) temperature
D) enthalpy
E) work

4) What is the thermodynamic definition of work? 4) _____

A) Work is equal to the internal energy of the system.
B) Work is the amount of energy transferred as heat.
C) Work is the same as the potential energy of the system.
D) Work is a force, acting through a distance.

5) Which of the following is the best example of an isolated system? 5) _____

A) water in a styrofoam coffee cup
B) liquid in a beaker with a watch glass over it
C) soda in an unopened soft drink can
D) coffee in a closed thermos bottle

6) How does a closed system differ from an open system? 6) _____

A) A closed system does not do any work on the surroundings.
B) A closed system cannot exchange heat with the surroundings.
C) Energy is conserved in a closed system.
D) A closed system cannot exchange matter with the surroundings.

7) A chemical reaction where heat is transferred to the surroundings is a(n) 7) _____

A) thermochemical equation.
B) endothermic reaction.
C) exothermic reaction.
D) energy-producing reaction.

8) Which of the following is an endothermic process? 8) _____

A) Jet fuel burning in a jet engine
B) Combustion of methane
C) Freezing of water
D) Vaporization of water

9) Which of the following is true if $\Delta H = -95$ J? 9) _____

A) Both the system and the surroundings are gaining 95 J.
B) Both the system and the surroundings are losing 95 J.
C) The system is gaining 95 J, while the surroundings are losing 95 J.
D) The system is losing 95 J, while the surroundings are gaining 95 J.

10) Which of the following signs on q and w represent a system that is doing work on the surroundings, as well as losing heat to the surroundings? 10) _____

A) +q , +w
B) −q , −w
C) +q , −w
D) −q , +w
E) None of the above.

11) How much work is done when a piston expands from a volume of 13.27 liters to 76.55 liters against a pressure of 14.89 atm? 11) _____

$W = -P\Delta V$

$W = -(14.89\,atm)(76.55L - 13.27L)$

$W = -942.2\,L\cdot atm$

$-942.2\,L\cdot atm \times \frac{101.3\,J}{L\cdot atm} \times \frac{kJ}{10^3\,J} = -95.45\,kJ$

12) How much work in joules is done on the system when a 1.15 atm external pressure causes a piston to decrease in volume from 6.55 liters to 3.16 liters? 12) _____

$W = -P\Delta V$

$W = -(1.15\,atm)(3.16L - 6.55L)$

$W = 3.90\,L\cdot atm \times \frac{101.3\,J}{L\cdot atm} = 395\,J$

13) In a refrigeration system, the refrigerant gas absorbs 21,390 J of energy while expanding against a 0.278 atmosphere pressure from a volume of 0.0423 liters to a volume of 1.876 liters. What is the energy change of the gas? 13) _____

$\Delta E = \Delta H - P\Delta V$

$\Delta E = (21390\,J) - (0.278\,atm)(1.876L - 0.0423L)$

$\Delta E = 21390\,J - 51.6\,J = 21338\,J \Rightarrow 21.338\,kJ$

14) What is the energy change of the system if a chemical reaction transfers 32,146 J of heat to the surroundings while it causes the expansion of a 1.465 liter vessel to 3.687 liters against a pressure of 3.64 atmospheres? 14) _____

$\Delta E = \Delta H - P\Delta V$

$\Delta E = (-32146\,J) - (3.64\,atm)(3.687L - 1.465L)$

$\Delta E = -32146\,J - 819\,J = -32965\,J \Rightarrow -32.965\,kJ$

15) Use the $\Delta H°_f$ information provided to calculate $\Delta H°_{rxn}$ for the following: 15) _____

$SO_2Cl_2\ (g) + 2\ H_2O(l) \rightarrow 2\ HCl(g)\ + H_2SO4(l)$ $\Delta H°_{rxn} = ?$

	$\Delta H°_f$ (kJ/mol)
$SO_2Cl_2(g)$	-364
$H_2O(l)$	-286
$HCl(g)$	-92
$H_2SO_4(l)$	-814

$\Delta H° = [(2\,mol)(-92\,kJ/mol) + (1\,mol)(-814\,kJ/mol)] - [(1\,mol)(-364\,kJ/mol) + (2\,mol)(-286\,kJ/mol)] = -62\,kJ$

16) Use the information provided to determine $\Delta H°_{rxn}$ for the following reaction: 16) _____

$CH_4(g) + 4\ Cl_2(g) \rightarrow CCl_4(g)\ + 4\ HCl(g)$ $\Delta H°_{rxn} = ?$

	$\Delta H°_f$ (kJ/mol)
$CH_4(g)$	-75
$CCl_4(g)$	-96
$HCl(g)$	-92

$\Delta H° = [(1\,mol)(-96\,kJ/mol) + (4\,mol)(-92\,kJ/mol)] - [(1\,mol)(-75\,kJ/mol)] = -389\,kJ$

17) Use the information provided to determine $\Delta H°_{rxn}$ for the following reaction: 17) _____

$3\ Fe_2O_3(s) + CO(g) \rightarrow 2\ Fe_3O_4(s) + CO_2(g)$ $\Delta H°_{rxn} = ?$

	$\Delta H°_f$ (kJ/mol)
$Fe_2O_3(s)$	-824
$Fe_3O_4(s)$	-1118
$CO(g)$	-111
$CO_2(g)$	-394

$\Delta H° = [(2\,mol)(-1118\,kJ/mol) + (1\,mol)(-394\,kJ/mol)] - [(3\,mol)(-824\,kJ/mol) + (1\,mol)(-111\,kJ/mol)] = -47\,kJ$

18) Use the standard reaction enthalpies given below to determine $\Delta H°_{rxn}$ for the following reaction: 18) _____

$2\ NO(g) + O_2(g) \rightarrow 2\ NO_2(g)$ $\Delta H°_{rxn} = ?$

Given:

$N_2(g) + O_2(g) \rightarrow 2\ NO(g)$ $\Delta H°_{rxn} = +183$ kJ ← FLIP

$1/2\ N_2(g) + O_2(g) \rightarrow NO_2(g)$ $\Delta H°_{rxn} = +33$ kJ ← DOUBLE

$2NO \rightarrow N_2 + O_2$ $\Delta H° = -183\,kJ$

$N_2 + 2O_2 \rightarrow 2NO_2$ $\Delta H° = 66\,kJ$

$2NO + O_2 \rightarrow 2NO_2$ $\Delta H° = -117\,kJ$

19) Use the standard reaction enthalpies given below to determine $\Delta H°_{rxn}$ for the following reaction: 19) _____

$P_4(g) + 10\ Cl_2(g) \rightarrow 4PCl_5(s)$ $\Delta H°_{rxn} = ?$ $\Delta H° = -1835$ KJ

Given:

$PCl_5(s) \rightarrow PCl_3(g) + Cl_2(g)$ $\Delta H°_{rxn} = +157$ kJ ← FLIP, MULTIPLY BY 4

$P_4(g) + 6\ Cl_2(g) \rightarrow 4\ PCl_3(g)$ $\Delta H°_{rxn} = -1207$ kJ

20) Use the $\Delta H°_f$ and $\Delta H°_{rxn}$ information provided to calculate $\Delta H°_f$ for IF: 20) _____

$IF_7(g) + I_2(g) \rightarrow IF_5(g) + 2\ IF(g)$ $\Delta H°_{rxn} = -89$ kJ

	$\Delta H°_f$ (kJ/mol)
$IF_7(g)$	-941
$IF_5(g)$	-840

$(-89\text{ kJ}) = \left[(1\text{ mol})(-840\text{ kJ/mol}) + (2\text{ mol})(\Delta H°_{f_{IF}})\right] - \left[(1\text{ mol})(-941\text{ kJ/mol})\right] \Rightarrow \Delta H°_{f_{IF}} = -95$ kJ/mol

21) How much energy is released during the formation of 98.7 g of Fe, according to the reaction below? 21) _____

$Fe_2O_3(s) + 2\ Al(s) \rightarrow Al_2O_3(s) + 2\ Fe(s)$ $\Delta H°_{rxn} = -852$ kJ A "THERMITE" REACTION

$$98.7\text{ g} \times \frac{\text{mol Fe}}{55.847\text{ g}} \times \frac{852\text{ kJ}}{2\text{ mol Fe}} = 753\text{ kJ}$$

22) Using the following information, what mass of HF must react in order to produce 345 kJ of energy? Assume excess SiO_2. 22) _____

$SiO_2(s) + 4\ HF(g) \rightarrow SiF_4(g) + 2\ H_2O(l)$ $\Delta H°_{rxn} = -184$ kJ

$$345\text{ kJ} \times \frac{4\text{ mol HF}}{184\text{ kJ}} \times \frac{20.01\text{ g}}{\text{mol HF}} = 1.50 \times 10^2\text{ g}$$

23) Using the following information, what mass of H_2O must form in order to produce 975 kJ of energy? 23) _____

$SiO_2(s) + 4\ HF(g) \rightarrow SiF_4(g) + 2\ H_2O(l)$ $\Delta H°_{rxn} = -184$ kJ

$$975\text{ kJ} \times \frac{2\text{ mol } H_2O}{184\text{ kJ}} \times \frac{18.016\text{ g}}{\text{mol } H_2O} = 191\text{ g}$$

24) How much energy can be relased if 32.5 g of B_2H_6 and 72.5 g of Cl_2 are allowed to react according to the following reaction? The molar mass of B_2H_6 is 27.67 g/mol. 24) _____

$$B_2H_6(g) + 6\,Cl_2(g) \rightarrow 2\,BCl_3(g) + 6\,HCl(g) \qquad \Delta H°_{rxn} = -1396\ kJ$$

$32.5\,g \times \frac{mol\ B_2H_6}{27.67\,g} \times \frac{1396\ kJ}{mol\ B_2H_6} = 1640\ kJ$

$72.5\,g \times \frac{mol\ Cl_2}{70.905\,g} \times \frac{1396\ kJ}{6\ mol\ Cl_2} = 238\ kJ$ ← HOW MUCH CAN BE PRODUCED

25) How much energy can be relased during the following reaction if 2.50 L B_2H_6 and 5.65 L Cl_2 (Both gases are initially at STP), are allowed to react? 25) _____

$$B_2H_6(g) + 6\,Cl_2(g) \rightarrow 2\,BCl_3(g) + 6\,HCl(g) \qquad \Delta H°_{rxn} = -1396\ kJ$$

$2.50\,L \times \frac{mol\ B_2H_6}{22.41\,L} \times \frac{1396\ kJ}{mol\ B_2H_6} = 156\ kJ$ ← HOW MUCH CAN BE PRODUCED

$5.65\,L \times \frac{mol\ Cl_2}{22.41\,L} \times \frac{1396\ kJ}{mol\ Cl_2} = 352\ kJ$