Chem 112-2014 Name: ANSWER KEY

Vining- Exam #1 February 7, 2014

1. Specific heat capacity is

a) the quantity of heat needed to change the temperature of 1.00 g of a substance by 1.00 K.

Note: This is the same as changing the temperature by 1 °C.

2. If 245 J is required to change the temperature of 14.4 g of chromium by 38.0 K, what is the specific heat capacity of chromium?

$$\text{specific heat} = \frac{245J}{14.4g \times 38.0K} = 0.448J / g \cdot K$$

a) 0.448 J/g·K

3. What quantity of energy is required to heat 50.0 g of water from 25.0 °C to 95 °C?

#J = 4.184 J/g·°C x 50.0 g x 70 °C = 14600 J

a) 14600 J

4. Determine the heat of condensation of titanium(IV) chloride,

$TiCl_4(g) \rightarrow TiCl_4(\ell)$ $\Delta H° = ?$

given the enthalpies of reaction below.

$Ti(s) + 2\ Cl_2(g) \rightarrow TiCl_4(\ell)$ $\Delta H° = -804.2$ kJ

$Ti(s) + 2\ Cl_2(g) \rightarrow TiCl_4(g)$ $\Delta H° = -763.2$ kJ

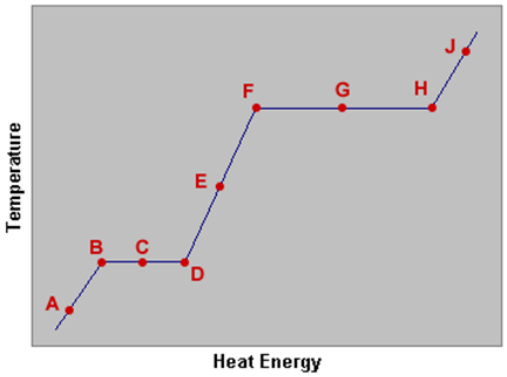
Need to reverse the bottom reaction, thereby changing its sign:

~~$Ti(s) + 2\ Cl_2(g)$~~ $\rightarrow TiCl_4(\ell)$ $\Delta H° = -804.2$ kJ

$TiCl_4(g) \rightarrow$ ~~$Ti(s) + 2\ Cl_2(g)$~~ $\Delta H° = +763.2$ kJ = sum = -41.0 kJ

b) -41.0 kJ

5. Which portion on the heating curve below represents melting ice and warming the liquid that forms?



c) CF

Segment C-D is melting ice. Segment D-F is heating liquid water. All the others involve either the solid or gaseous phases.

6. When 10.0 g KOH is dissolved in 100.0 g of water in a coffee-cup calorimeter, the temperature rises from 25.18 °C to 47.53 °C. What is the enthalpy change per gram of KOH dissolved in the water? Assume that the solution has a specific heat capacity of 4.18 J/g·°C. Assume the cup absorbs no heat.

$$\Delta H = -\frac{\#J}{\#g} = \frac{4.18\ J/g\cdot^{o}C \times 110.0g \times 22.35^{o}C}{10.0g\ \text{KOH}} = -1030J/g$$

c) -1.03×10^3 J/g

7. Which of the following chemical equations corresponds to the standard molar enthalpy of formation of SO_3?

A formation reaction is one that forms 1 mol of a compound from its elements in their natural state.

e) $S(s) + 3/2\ O_2(g) \rightarrow SO_3(g)$

8. Calculate $\Delta H°$ for the reaction below,

$$Fe_2O_3(s) + 3\ H_2(g) \longrightarrow 2\ Fe(s) + 3\ H_2O(g)$$

using standard molar enthalpies of formation.

molecule	$\Delta H_f°$ (kJ/mol)
$Fe_2O_3(s)$	-824.2
$H_2O(g)$	-241.8

The enthalpy of formation of elements in their natural states are zero. So,

ΔH = [2(0) + 3x(-241.8 kJ)] – [-824.2 kJ + 3(0)] = +98.8

e) 98.8 kJ

9. Calculate the enthalpy change (ΔH) for the reaction below,

$$Br_2(g)\ +\ 3\ F_2(g)\ \rightarrow\ 2\ BrF_3(g)$$

given the bond enthalpies of the reactants and products.

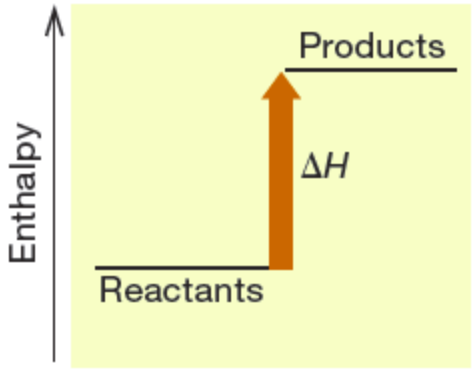
Bond	Bond Enthalpy (kJ/mol·rxn)
Br-Br	193
F-F	155
Br-F	249

Need to draw out molecules. Bonds broken = 1 Br-Br + 3 F-F.
Bonds formed = 6 Br-F
ΔH = [193 + 3(155)] – [6(249)] = -836 kJ

a) -836 kJ

10. Consider the enthalpy diagram here. What can be said of a system this diagram represents?

d) thermal energy is absorbed and the system is endothermic



11. The specific heat capacity of Al is 0.897 J/g ^{o}C. That of Cu is 0.385 J/g ^{o}C.

What will the final temperature be if a 10-g block of Al at 0 ^{o}C is allowed to thermally equilibrate with a 10-g block of Cu at 100 ^{o}C?

With the same mass, the block with the greater specific heat capacity will have the smaller temperature change. 50 oC is the midpoint between the two starting temperatures, so the final temperature will be closer to that of Al. Therefore, the final temperature is between 0 ^{o}C and 50 ^{o}C.

d) greater than 0 ^{o}C but less than 50 ^{o}C

12. You have two samples of gas, O_2 at 250 K and CO_2 at 250 K. Which is true?

Average kinetic energy depends only on temperature. With the same energy, the more massive molecules move more slowly.

c) they have equal kinetic energy and O_2 has greater average molecular speed

13. You fill a balloon with 2.50 moles of gas at 22°C at a pressure of 1.62 atm. What is the volume of the balloon?

$$V = \frac{nRT}{P} = \frac{2.50mol \times 0.082057L \cdot atm / K \cdot mol \times 295K}{1.62atm} = 37.4L$$

c) 37.4 L

14. Which gas has the greatest density at room temperature and pressure?

All gases take up the same volume per mole. Therefore the most dense gas is that with the greatest molar mass. Of these, it is Cl_2.

b) Cl_2

15. The mass of 1.12 liters of a gas at 1.00 atm and 0 °C is found to be 6.23 g. What is the molar mass of the gas?

$$n = \frac{PV}{RT} = \frac{1.00atm \times 1.12L}{R \times 273K} = 0.050\ mol$$

$$\text{molar mass} = \frac{\#g}{\#mol} = \frac{6.23g}{0.050\ mol} = 125\ g/mol$$

c) 125 g/mol

16. A gas sample is heated from -20.0°C to 57.0°C and the volume is increased from 2.00 L to 4.50 L. If the initial pressure is 0.140 atm, what is the final pressure?

$$P_2 = P_1 \times \frac{T_2}{T_1} \times \frac{V_1}{V_2} = 0.140\ atm \times \frac{330K}{253K} \times \frac{2.00L}{4.50L} = 0.0811\ atm$$

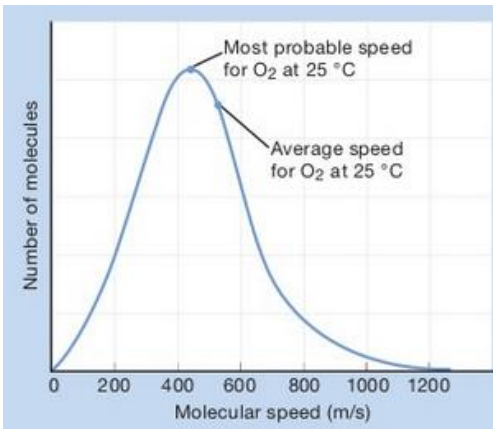
e) 0.0811 atm

17. What is the root-mean-square velocity of oxygen (O_2) gas at a temperature of 492 K?

$$v_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3 \times 8.314J/K \cdot mol \times 492K}{0.032kg/mol}} = 619m/s$$

b) 619 m/s

18. The plot here shows the Boltzmann distribution curve for O_2 gas at 25 °C. Which would be true for CO_2 gas at 25 °C and for O_2 at 75 °C?



Heavier gases (CO_2) move more slowly; gases at higher temperature (O_2 at 50 °C) move faster.

c) the curve for CO_2 gas at 25 °C would be to the left and for O_2 at 75 °C would be to the right

19. Gases at relatively low temperatures can exhibit nonideal behavior. Which describes this behavior and its cause?

At low temperatures, molecules interact with one another. This lowers the effective number of moles of gas present. As n decreases, P decreases.

d) pressure is lower due to intermolecular interactions

Long Answer Question: You Must Show all your work

A 1.34-g sample contains a mixture of $CaCO_3$ and $CaCl_2$. The sample is heated in a sealed container and the following reaction occurs to the $CaCO_3$. The $CaCl_2$ does not react.

$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

The final state of the reaction vessel shows: Volume = 1.68 L
Temperature = 120 ^oC
Pressure of CO_2 = 32.1 mm Hg

What is the mass percent of $CaCO_3$ in the sample?

Problem map: gas data → mol CO_2 → mol $CaCO_3$ → g $CaCO_3$ → %$CaCO_3$

Use the gas data to determine moles of CO_2 produced in the reaction.

$$n = \frac{PV}{RT} = \frac{0.0422\ atm \times 1.68\ L}{R \times 393K} = 0.00220\ mol\ CO_2$$

$$0.00220\ mol\ CO_2 \times \frac{1\ mol\ CaCO_3}{1\ mol\ CO_2} = 0.00220\ mol\ CaCO_3$$

$$0.00220\ mol\ CaCO_3 \times \frac{100.08g}{1\ mol\ CaCO_3} = 0.220g\ CaCO_3$$

$$\%CaCO3 = \frac{0.220g\ CaCO_3}{1.34g\ sample} \times 100\% = 16.4\%$$