1. Urea (H_2NCONH_2) is used extensively as a nitrogen source in fertilizers. It is produced commercially from the reaction of ammonia and carbon dioxide.

   $$2\ NH_3\,(g) + CO_2\,(g) \rightarrow H_2NCONH_2\,(s) + H_2O\,(g)$$

   Ammonia is added to an evacuated 5.0-L flask, to a pressure of 8.0 atm, at a temperature of 20°C. Carbon dioxide is added to the ammonia, to give a total pressure of 11 atm. The flask is then heated. What mass of urea is produced in this reaction, assuming 100% yield?

2. A compound consists of 37.5% C, 3.15% H, and 59.3% F by mass. When 0.298 g of the compound is heated to 50 °C in an evacuated 125-mL flask, the pressure is observed to be 750 mm Hg. What is the molar mass, empirical formula, and molecular formula of the compound?

3. Consider the following information for the formation of sulfur trioxide:

   $S\,(s) + 3\ O_2\,(g) \rightarrow 2\ SO_3\,(g) \qquad \Delta H° = -791$ kJ

   The standard enthalpy of formation for SO_3 is –395.72 kJ mol^{-1}. Why are the enthalpy values different?

4. A solution is made by mixing 200 mL 0.20 M NaOH with 100 mL 0.10 M HNO_3. Find the number of moles of each ion and its concentration in the solution after reaction is complete.

5. Are the following reactions exothermic or endothermic?

   a. $CCl_3CHCl_2\,(g) + 2\ HF\,(g) \rightarrow CCl_3CHF_2\,(g) + 2\ HCl\,(g) \qquad \Delta H = -24$ kJ mol^{-1}

   b. $H_2(g) \rightarrow 2\ H(g) \qquad \Delta H = +436$ kJ mol^{-1}

   c. $2\ H(g) \rightarrow H_2(g)$

6. At 0°C, <u>each cubic centimeter</u> of a 1.0-L flask contains 5.0×10^{-2} mol N_2, 1.5×10^2 mg O_2, and 5.0×10^{18} molecules NO. What is the partial pressure of each gas, and what is the total pressure in the flask?

7. Which of the following gases would have the smallest kinetic energy?

   (a) He @ 50°C (b) Ne @ 50°C (c) H_2 @ 0°C (c) CO_2 @ 150°C

8. A balloon is filled to a volume of 6.00×10^2 mL at a temperature of 20.0°C. The balloon is then cooled to a temperature of 1.0×10^2 K. What is the final volume?

9. Consider a 1.0-L container of neon gas at STP. Will the average kinetic energy increase, decrease, or remain the same under each of the following conditions:

   (a) The temperature is increased by 100°C.
   (b) The temperature is decreased by 50°C.
   © The volume is decreased to 0.5 L (constant T)

10. Iron can react with oxygen to give iron(III) oxide. What is the enthalpy of the reaction if 5.58 g of Fe is heated in pure O_2? $4\ Fe\,(s) + 3\ O_2\,(g) \rightarrow 2\ Fe_2O_3\,(s) \qquad \Delta H = -1648.4$ kJ

11. It is found that 22.3 mL of 0.240 M NaOH is required to completely react with a 50.0-mL sample of vinegar, a solution of acetic acid in water. The net ionic equation for the reaction is

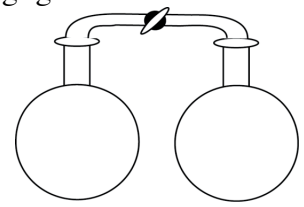
    $$HC_2H_3O_{2(aq)} + OH^-_{(aq)} \rightarrow C_2H_3O_2^-{}_{(aq)} + H_2O_{(\ell)}$$

    Calculate the concentration of acetic acid in the vinegar.

12. If the air we breathe is 78% N_2 and 22% O_2 on a mole basis, what is the mole fraction of O_2? What is the partial pressure of O_2 if the total pressure is 0.947 atm?

13. What volume of each of the following acids will react completely with 50.00 mL of 0.200 M NaOH?
(a) 0.100 M HCl (b) 0.0598 M HNO_3 (c) 1.23 M H_2SO_4

14. Consider the two flasks in the diagram below. Once the stopcock (valve) connecting the two flasks is opened, what is the partial pressure of each gas and the total pressure in the resulting system? Assume the connecting tubes have negligible volume.



Ar	O_2
1.8 L	2.2 L
0.243 atm	1.077 atm

15. Based on your experience, when ice melts to liquid water is the process exothermic or endothermic (with respect to the ice)? When liquid water freezes to ice at 0°C, is this exothermic or endothermic (with respect to the liquid water)?

16. Acid spills are often neutralized with sodium carbonate. For neutralization of acetic acid, the unbalanced equation is $CH_3CO_2H\,(\ell) + Na_2CO_3\,(s) \rightarrow CH_3CO_2Na\,(aq) + CO_2\,(g) + H_2O\,(\ell)$
a. If ΔH for the above reaction is –516.3 kJ, how much heat is transferred when 0.5000 mol of acetic acid is completely neutralized?
b. Is this reaction endothermic or exothermic?

17. A 115-mg sample of eugenol, the compound responsible for the odor of cloves, was placed in an evacuated flask with a volume of 500.0 mL at 280.0°C. The pressure eugenol exerted in the flask under those conditions was found to be 48.3 Torr. In a combustion experiment, 18.80 mg of eugenol burned to give 50.39 mg of carbon dioxide and 12.38 mg of water. What is the molecular formula of eugenol?

KEY

1. 37 g urea 2. Molar mass = 64.0 g mol^{-1}, Empirical Formula = CHF, Molecular Formula = $C_2H_2F_2$
3. The equation for the formation of SO_3 would be ½ S (s) + 3/2 O_2 (g) → SO_3 (g). ΔH_f assumes formation of 1 mol of product.
4. 0.010 mol NO_3^- in sol'n, $[NO_3^-]$ = 0.033 M; 0.040 mol Na^+ in sol'n, $[Na^+]$ = 0.13 M; 0.030 mol OH^- in sol'n, $[OH^-]$ = 0.10 M
5. (a) exothermic (b) endothermic (c) exothermic
6. $P_{tot} = 1.2 \times 10^3$ atm, $P_{N2} = 1.1 \times 10^3$ atm, $P_{O2} = 1.1 \times 10^2$ atm, $P_{NO} = 0.19$ atm 7. (c) 8. $V_f = 2.0 \times 10^2$ mL or 0.20 L
9. (a) increase (b) decrease (c) same 10. ΔH = –41.2 kJ 11. $[HC_2H_3O_2] = 0.107$ M
12. $X_{O2} = 0.22$, $P_{O2} = 0.21$ atm 13. (a) $V_{HCl} = 0.100$ L (b) $V_{HNO3} = 0.167$ L (c) $V_{HBr} = .00407$ L
14. $P_{Ar} = 0.11$ atm $P_{O2} = 0.59$ atm $P_{tot} = 0.70$ atm 15. Endothermic wrt ice; exothermic wrt liquid water
16. (a) 258.2 kJ transferred (ΔH = -258.2 kJ) (b) exothermic 17. $C_{10}H_{12}O_2$