# Exam 3a
# Chem 1141
# Fall 2008

Name: KEY

**MULTIPLE CHOICE.** [3 pts ea.]

Q1. The SI unit of pressure is the pascal (Pa). It is defined as being equal to:

a) 1 Pa = 1 N  b) 1 Pa = 1 N/s  (c) 1 Pa = 1 $N/m^2$

d) 1 Pa = 1 $m^2/N$  e) 1 Pa = 1 m/s

Q2. Which of the following elements is *not* found as a diatomic gas under regular conditions on earth:

a) nitrogen  (b) helium  c) hydrogen  d) oxygen  e) fluorine

Q3. The volume of a gas is directly proportion to its absolute temperature. This is commonly known as:

a) Avogadro's law  b) Boyle's law  (c) Charles' law

d) Gay-Lussac's law  e) van der Waal's law

Q4. Given the following chemical equation:

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

What volume of hydrogen gas is required to fully react with 3.0 L of nitrogen gas at STP?

a) 1.0 L  b) 3.0 L  c) 4.5 L  d) 6.0 L  (e) 9.0 L

Q5. Which pressure is the largest:

(a) 1 atm  b) 1 mmHg  c) 1 torr  d) 1 Pa

Q6. A 4.50 g sample of metal absorbs 76.0 J of heat, and changes in temperature from 24.0 °C to 155.1 °C. What is the specific heat capacity of the metal?

(a) 0.129 J/g·°C  b) 0.341 J/g·°C  c) 1.45 J/g·°C

d) 14.2 J/g·°C  e) 89 J/g·°C

Q7. Which chemical equation corresponds to the standard enthalpy of formation of $C_8H_{15}Cl(l)$?

a) $C_8H_{15}Cl(l) + 11\frac{1}{2}\ O_2(g) \rightarrow 8\ CO_2(g) + 7\ H_2O(l) + HCl(aq)$

b) $2\ C_8H_{15}Cl(l) + 23\frac{1}{2}\ O_2(g) \rightarrow 16\ CO_2(g) + 15\ H_2O(l) + Cl_2(g)$

c) $C_8H_{15}Cl(l) \rightarrow 8C(s, graphite) + 15H(g) + \frac{1}{2}\ Cl_2(g)$

d) $C_8H_{15}Cl(l) \rightarrow 8C(s, graphite) + 7\frac{1}{2}\ H_2(g) + \frac{1}{2}\ Cl_2(g)$

(e) $8C(s, graphite) + 7\frac{1}{2}\ H_2(g) + \frac{1}{2}\ Cl_2(g) \rightarrow C_8H_{15}Cl(l)$

Q8. A chemical reaction that absorbs heat is said to be:

a) Exoergic  b) Endoergic  c) Exothermic  (d) Endothermic

Q9. Which of the following standard enthalpy of formation values is not zero at 25 °C?

a) Na(s)  b) Ne(g)  (c) $CH_4(g)$  d) Hg(l)  e) $H_2(g)$

Q10. Calculate $\Delta H^\circ$ for the reaction:

$$2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$$

given that $\Delta H_f^\circ$ for $H_2O(l)$ is –285.8 kJ/mol.

a) –285.8 kJ/mol b) +285.8 kJ/mol c) +142.9 kJ/mol
d) –142.9 kJ/mol (e) +571.6 kJ/mol

Q11. A particle of light is called a(n):

a) Proton b) Electron c) Quantum d) Positron (e) Photon

Q12. Which form of electromagnetic (EM) radiation has the *longest* wavelength?

(a) Radio b) Ultraviolet c) Visible d) X-Ray e) Infrared

Q13. Which set of quantum numbers for an electron in an atom is *not* allowed:

a) $n = 3, l = 2, m_l = -1, m_s = +½$ b) $n = 1, l = 0, m_l = 0, m_s = -½$
c) $n = 4, l = 1, m_l = 0, m_s = +½$ (d) $n = 1, l = 1, m_l = 0, m_s = -½$
e) $n = 8, l = 6, m_l = -3, m_s = +½$

Q14. Atoms of neon are paramagnetic.

a) TRUE (b) FALSE

Q15. Atoms of oxygen are paramagnetic.

(a) TRUE b) FALSE

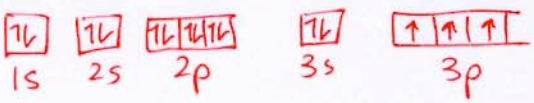
Q16. [8 pts.] Write the *full* electron configuration for

i) oxygen. $1s^2 2s^2 2p^4$

ii) copper $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$

iii) chlorine $1s^2 2s^2 2p^6 3s^2 3p^5$

Q17. [6 pts.] Draw an orbital diagram for an atom of phosphorus.




Q18. [8 pts.] Calculate the frequency of light emitted from a hydrogen atom undergoing an electron transition from $n = 5$ to $n = 2$.

$$\Delta E = E_f - E_i = -\frac{R_H}{2^2} \ominus -\frac{R_H}{5^2} = R_H\left(\frac{1}{25} - \frac{1}{4}\right) = -0.21 \times R_H$$

$$\Rightarrow \Delta E = -0.21 \times 2.18\times10^{-18}\ J = -4.58\times10^{-19}\ J.$$

-ve $\Rightarrow$ atom loses $4.58\times10^{-19}$ J of energy in the form of a photon.

$$E_{photon} = h\nu = 4.58\times10^{-19}\ J$$

$$\Rightarrow \nu = \frac{4.58\times10^{-19}\ J}{h} = \frac{4.58\times10^{-19}\ J}{6.626\times10^{-34}\ J\cdot s} = 6.91\times10^{14}\ s^{-1} \text{ or Hz.}$$

Q19. [5 pts.] A sample of an ideal gas whose volume is 45.6 mL at a temperature of 127 °C is cooled down to –87 °C. What will its new volume be?

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$ ? $\Rightarrow V_2 = \frac{V_1}{T_1} \times T_2 \Rightarrow V_2 = \frac{45.6\,mL}{400\,K} \times 186\,K$

$= 21.2\,mL$ (3 s.f.)

$T_1 = 127 + 273 = 400.\,K$

$T_2 = -87°C + 273 = 186\,K$

Q20. [8 pts.] How much heat will be absorbed/released from the complete combustion of 34.0 g of pentane, $C_5H_{12}(l)$.

$C_5H_{12}(l) + 8O_2(g) \rightarrow 5CO_2(g) + 6H_2O(l)$

$\Delta H_f^\circ\ C_5H_{12}(l) = -146.9$ kJ/mol  $\Delta H_f^\circ\ CO_2(g) = -393.5$ kJ/mol

$\Delta H_f^\circ\ H_2O(l) = -285.8$ kJ/mol

(element in most stable form) $= 0$

$\Delta H^\circ_{rxn} = \sum \Delta H_f^\circ (prods) - (reacts)$

$= \left[5 \times \Delta H_f^\circ (CO_{2(g)}) + 6 \times \Delta H_f^\circ (H_2O_{(l)})\right] - \left[1 \times \Delta H_f^\circ (C_5H_{12(l)}) + 8 \times \Delta H_f^\circ (O_{2(g)})\right]$

$= [5 \times -393.5 + 6 \times -285.8] - [1 \times -146.9] = -3535.4\,kJ/mol$

$\Delta H = q_p = \frac{-3535.4\,kJ}{1\,mol\ C_5H_{12}} \times \#mol\ C_5H_{12}$ // $34.0\,g\ C_5H_{12} \times \frac{1\,mol\ C_5H_{12}}{72.2\,g\ C_5H_{12}} = 0.4\,mol\ C_5$

$C_5H_{12}$

$5 \times C = 5 \times 12.01$

$12 \times H = 12 \times 1.01$

$72.2$

$\Rightarrow q = \frac{-3535.4\,kJ}{1\,mol\ C_5H_{12}} \times 0.471\,mol\ C_5H_{12}$

$q = -1670\,kJ$ (released)

Q21. [5 pts.] 34.5 mL of 12.0 M HCl(aq) is added to 128 mL of $H_2O$. Calculate the final concentration of HCl. State any assumptions that you are making.

$M_1V_1 = M_2V_2$

$12.0\,M$  $34.5\,mL$  ?

$34.5\,mL + 128\,mL = 163\,mL$ (assuming Volumes are additive!)

$\Rightarrow M_2 = \frac{M_1V_1}{V_2} = \frac{12.0\,M \times 34.5\,mL}{163\,mL} = 2.54\,M$

Q22. [10 pts.] What volume of $CO_2(g)$ will be formed by the reaction of 34.0 mL of 1.45 M HCl(aq) with 67.8 mL of 5.60 M $LiHCO_3(aq)$? The reaction is carried out at a temperature of 35 °C, and a pressure of 0.987 atm. Be sure to start by writing out the *balanced* chemical equation!

$HCl_{(aq)} + LiHCO_{3(aq)} \longrightarrow LiCl_{(aq)} + H_2O_{(l)} + CO_{2(g)}\uparrow$

$$34.0\,mL \left|\frac{10^{-3}L}{1\,mL}\right| \frac{1.45\,mol\,HCl}{1\,L} \left|\frac{1\,mol\,CO_{2(g)}}{1\,mol\,HCl}\right| = 0.0493\,mol\,CO_{2(g)}$$

$$67.8\,mL \left|\frac{10^{-3}L}{1\,mL}\right| \frac{5.60\,mol\,LiHCO_3}{1\,L} \left|\frac{1\,mol\,CO_{2(g)}}{1\,mol\,LiHCO_3}\right| = 0.380\,mol\,CO_{2(g)}$$

$\Rightarrow$ Actual #mol $CO_{2(g)} = 0.0493\,mol$

$pV = nRT \Rightarrow V = \frac{nRT}{p}$

$n = 0.0493\,mol$

$R = 0.08206\,\frac{atm \cdot L}{mol \cdot K}$

$T = 35 + 273 = 308\,K$

$p = 0.987\,atm$

$$\Rightarrow V = \frac{0.0493\,mol \times 0.08206\,\frac{atm \cdot L}{mol \cdot K} \times 308\,K}{0.987\,atm}$$

$$= 1.26\,L \quad (3\,s.f.)$$

Q23. [5 pts.] Name the following compounds:

a) $Na_3PO_4$ sodium phosphate

b) $Fe(NO_2)_2$ iron(II) nitrite

c) $MgF_2 \cdot 3H_2O$ magnesium fluoride trihydrate

d) $B_3Cl_9$ triboron nonachloride

e) $N_4O_8$ tetranitrogen octoxide