Chemistry – 4311
September 28, 2009

Exam #1 **Name** Key

(20) 1. Matching (use a letter only once)

700000 equals __a__.	a. 7×10^5
The energy of a photon is __e__.	b. $mv^2/2$
The relationship between the frequency and wavelength of light is __j__.	c. proportional
	d. wave properties
The average kinetic energy of an ideal gas molecule is __s__.	e. hν
de Broglie postulated that particles have __d__.	f. 7×10^{-5}
The ionization energy of Ne is __i__ than that of F.	g. 0 °C
In the van der Waals equation, *nb* corrects for the __k__ of the gas molecules.	h. mc^2
	i. larger
According to the ideal gas law equation, at constant P and n, V is __c__ to T.	j. $\nu = c/\lambda$
Absolute zero is __q__.	k. effective volume
The expression for pressure, volume work is __t__.	l. mass
	m. inversely proportional
$c = 3.00 \times 10^8$ m/s	n. $-V_{ex}\Delta P$
$h = 6.626 \times 10^{-34}$ J s	o. $\nu = \lambda/c$
R= 8.314 J/mol-K	p. attractive force
R= 1.987 cal/mol-K	q. -273.15 °C
R= 0.08206 L-atm/mol-K	r. smaller
$N_A = 6.02 \times 10^{23}$	s. $3k_BT/2$
1 atm = 101.325 kPa	t. $-P_{ex}\Delta V$
$k_B = 1.381 \times 10^{-23}$ J/K	

(15) 2. State what each of the following equations represent. For example, for PV = nRT you would write the ideal gas law equation.

a. $\Delta x \Delta p \geqslant h/4\pi$,

Heisenberg Uncertainty Principle

b. $E_n = n^2h^2/8mL^2$, Energy levels for the particle in the box

c. $-(h^2/8\pi^2 m)(d^2\Psi/dx^2) + V\Psi = E\Psi$,

Schrödinger (wave) equation

d. $\lambda = h/p$, de Broglie's postulate for wave length (wave properties) of particles.

e. $E_n = -hcR_H/n^2$,

Energy levels for the H-atom

(10) 3. This question refers to the quantum numbers for the H-atom.

a. If the quantum number *n* is 3, what are the possible values for the quantum number *l*.

0, 1, 2

b. If the quantum number *l* is 2, what are the possible values for the quantum number m_l?

-2, -1, 0, 1, 2 — these are for the d-orbitals

(15) 4. An atom undergoes a transition between two energy levels and emits a photon of light with energy 4.57×10^{-19} J.

a. What is the frequency of the light that is emitted?

(+8)

$\Delta E = h\nu$

$4.57\times10^{-19}\ J = 6.626\times10^{-34}\ J\cdot s\ \ \nu$

$\nu = 6.90\times10^{14}$ cycles/s

b. What is the wave length of the light that is emitted?

(+7)

$\nu = c/\lambda$

$6.90\times10^{+14}\ s^{-1} = \dfrac{3.00\times10^{8}\ m/s}{\lambda}$

$\lambda = 4.35\times10^{-7}\ m$

(25) 5. A gas sample contains 25 grams of N_2 and 15 grams of O_2. The volume is 1 L and the temperature 25 °C.

a. What are the number of moles of N_2 and of O_2?

$N_2 = 28$ g/mole

$O_2 = 32$ g/mole

$n_{N_2} = 25/28 = 0.89$ moles

$n_{O_2} = 15/32 = 0.47$ moles

$n_T = 1.36$

b. What is the pressure of the gas sample?

$PV = n_T RT$

$$P = \frac{1.36 \times 0.08206 \times 298}{1\,L} = 33.3 \text{ atm}$$

c. What are the pressures of N_2 and O_2 in the gas sample?

$X_{N_2} = 0.89/1.36 = 0.65$ $\quad P_{N_2} = 0.65 \times 33.3 = 21$ atm

$X_{O_2} = 0.47/1.36 = 0.35$ $\quad P_{O_2} = 0.35 \times 33.3 = 12$ atm

(20) 6. The expression for the collision number is $Z_1 = \sqrt{2}\pi d^2\bar{c}(N/V)$, where $\bar{c} = (8RT/\pi M)^{1/2}$.

a. Show for He and Ne with the same concentration (N/V) that

$$Z_{1,He}/Z_{1,Ne} = (d_{He}/d_{Ne})^2(M_{Ne}/M_{He})^{1/2}$$

$$\frac{Z_{He}}{Z_{Ne}} = \frac{\sqrt{2}\pi d_{He}^2 \bar{c}_{He} (N/V)_{He}}{\sqrt{2}\pi d_{Ne}^2 \bar{c}_{Ne} (N/V)_{Ne}} = \left(\frac{d_{He}}{d_{Ne}}\right)^2 \frac{\bar{c}_{He}}{\bar{c}_{Ne}} = \left(\frac{d_{He}}{d_{Ne}}\right)^2 \left(\frac{M_{Ne}}{M_{He}}\right)^{1/2}$$

$$\frac{\bar{c}_{He}}{\bar{c}_{Ne}} = \frac{(8RT/\pi M_{He})^{1/2}}{(8RT/\pi M_{Ne})^{1/2}} = \left(\frac{M_{Ne}}{M_{He}}\right)^{1/2}$$

b. What does d_{He}/d_{Ne} have to equal for He and Ne to have the same collision number?

$$1 = \left(\frac{d_{He}}{d_{Ne}}\right)^2 \left(\frac{20.18}{4.00}\right)^{1/2} = \left(\frac{d_{He}}{d_{Ne}}\right)^2 \times 2.246$$

$$\frac{d_{He}}{d_{Ne}} = \left(\frac{1}{2.246}\right)^{1/2} = 0.667$$