General Chemistry 1 *(CHEM 1141)*

Shawnee State University – Fall 2021

November 9, 2021

Exam # 3B

Name KEY

Please write your full name, and the exam version (3B) that you have on the scantron sheet !

Please ☑ check the box next to your correct section number.

Section #:

❒ 1. (Monday Lab, Fleeman)

❒ 2. (Wednesday Lab, Fleeman)

❒ 3. (Monday Lab, Napper)

❒ 4. (Wednesday Lab, Napper)

Multiple Choice:	______	**/ 50**
Q21:	______	**/ 10**
Q22:	______	**/ 10**
Q23:	______	**/ 10**
Q24:	______	**/ 10**
Q25:	______	**/ 10**
BONUS:	______	**/ 3**
TOTAL:	______	**/ 100**

Each problem in this section (multiple choice) is worth 2.5 points !

Q1. In thermodynamics, a system that can exchange heat with its surroundings, but not matter, classified as:

A) Closed

B) Open

C) Isolated

D) Ideal

E) Exothermic

Q2. Which gas has molecules with the *greatest average molecular speed* at 25°C?

A) CH_4 — lowest molar mass $KE \propto T$

$\propto 1/M_0$

B) Kr

C) N_2

D) CO_2

E) Ar

Q3. Samples of the following volatile liquids are opened simultaneously at one end of a room. If you are standing at the opposite end of this room, which species would you smell first? (Assume that your nose is equally sensitive to all these species.)

A) ethyl acetate ($CH_3COOC_2H_5$)   lowest M_0 will move fastest!

B) camphor ($C_{10}H_{16}O$)

C) diethyl ether ($C_2H_5OC_2H_5$)

D) naphthalene ($C_{10}H_8$)

E) pentanethiol ($C_5H_{11}SH$)

Q4. A sample of pure oxygen gas has a pressure of 795 torr. What is the pressure of the oxygen in units of atmospheres?

A) 0.795 atm

$795 \text{ torr} \times \frac{1 \text{ atm}}{760 \text{ torr}} = 1.05 \text{ atm}$

B) 1.05 atm

C) 0.604 atm

D) 0.760 atm

E) 1.01 atm

Q5. At constant temperature and volume, a sample of oxygen gas is added to a sample of nitrogen gas. The pressure of the mixture is found by adding the pressures of the two individual gases. This is an example of:

A) Boyle's Law

B) Charles's Law

C) Gay-Lussac's Law

D) Avogadro's Law

E) Dalton's Law

Q6. A 45 mL sample of nitrogen gas is cooled from 135°C to 15°C in a container that can contract or expand at constant pressure. What is the new volume of the nitrogen gas?

A) 64 mL

$\frac{V_1}{T_1} = \frac{V_2}{T_2} \rightarrow V_2 = \frac{V_1 \times T_2}{T_1}$

B) 5.0 mL

C) 410 mL

$= \frac{45 \text{ mL} \times (15+273) \text{ K}}{(135+273) \text{ K}}$

D) 32 mL

E) 41 mL

$= 32 \text{ mL}$

Q7. Three separate 3.5g blocks of Al, Cu, and Fe at 25°C each absorb 0.505 kJ of heat. Which block reaches the highest temperature? The specific heats of Al, Cu, and Fe are 0.900 J/g·°C, 0.385J/g·°C, and 0.444 J/g·°C, respectively.

Cu (smallest)

$q = m \cdot s \cdot \Delta t$

$\rightarrow \Delta t = \frac{q}{ms}$ — same

same

$\Delta t \propto 1/s$

A) Al

B) Cu

C) Fe

D) Al and Cu

E) Fe and Cu

Q8. The reaction that represents the **standard enthalpy of formation** for benzene (C_6H_6) is:

form 1 mole from most stable elements

A) $6\ C(diamond) + 3\ H_2(g) \rightarrow C_6H_6(l)$

B) $6\ C(graphite) + 6\ H(g) \rightarrow C_6H_6(l)$

C) $C_6H_6(l) + 15/2\ O_2(g) \rightarrow 6\ CO_2(g) + 3\ H_2O(g)$

D) $6\ C(graphite) + 3\ H_2(g) \rightarrow C_6H_6(l)$

E) $C_6H_6(l) \rightarrow 6\ C(graphite) + 3\ H_2(g)$

Q9. What is the device called that is used to measure air pressure?

A) Manometer

B) Barometer

C) Goniometer

D) Torricelliner

E) Spingometer

Q10. Concerning the reaction

$$C(\text{graphite}) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H^\circ = -393 \text{ kJ/mol}$$

How many grams of C(graphite) must be burned to release 275 kJ of heat?

$$-275\text{kJ} \times \frac{1\text{mol C}}{-393\text{kJ}} \times \frac{12.01\text{g C}}{1\text{mol C}} = 8.40\text{g C}$$

A) 0.70 g

B) 8.40 g

C) 12.0 g

D) 17.1 g

E) 22.3 g

Q11. The van der Waals equation is a modification of the ideal gas equation. What two factors does this equation account for?

A) (1) Real gas molecules exert forces on each other. (2) Gas molecules have energy.

B) (1) Real gas molecules exert ionic forces on each other. (2) Gas molecules have energy.

C) (1) Real gas molecules exert forces on each other. (2) Gas molecules have volume.

D) (1) Real gas molecules exert ionic forces on each other. (2) Gas molecules have volume.

E) None of the above have BOTH of the two factors accurately stated.

Q12. Which one of the following is not an example of an element that occurs as a gas at room temperature and pressure?

A) helium $He(g)$

B) neon $Ne(g)$

C) nitrogen $N_2(g)$

D) fluorine $F_2(g)$

E) mercury $Hg(l)$

Q13. A sample of gas has a total pressure of 1250 mmHg. If it consists of 1.20 mol hydrogen, 3.25 mol oxygen, and 2.55 mol argon—calculate the partial pressure of oxygen in the sample.

$P_{O_2} = x_{O_2} \times P_{TOT}$

$= \frac{3.25\,mol}{3.25\,mol + 1.20\,mol + 2.55\,mol} \times 1250\,mmHg$

$= 580.\,mmHg$

A) 4060 mmHg

B) 385 mmHg

C) 1080 mmHg

D) 580. mmHg

E) 290. mmHg

Q14. According to the kinetic molecular theory of gases, the average kinetic energy of a gas molecule is **proportional** to its:

$KE \propto T(K)$

A) pressure (atm)

B) temperature (K)

C) #moles (mol)

D) volume (L)

E) mole fraction (x)

Q15. How much heat will be absorbed if 1.00 mol NH_3 is formed according to the following thermochemical equation:

$$N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)\ ;\ \Delta H = +90.\ kJ/mol$$

$1.00\,mol\ NH_3 \times \frac{90\,kJ}{2\,mol\ NH_3} = 45\,kJ$

A) 90. kJ

B) 180 kJ

C) 45 kJ

D) 2.00 kJ

E) 1.00 kJ

Q16. Which substance has a standard enthalpy of formation of zero?

A) $H_2(l)$ $H_2(g)$

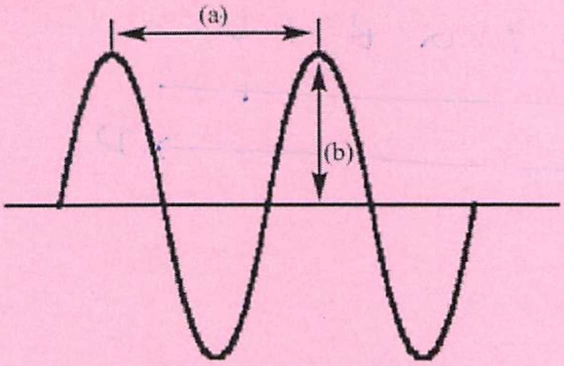
B) $Hg(s)$ $Hg(l)$

C) $Ne(g)$ ← element in most stable form

D) $CH_3OH(l)$ not element

E) $O_3(g)$ $O_2(g)$

Q17. In the following diagram of a wave



A) (a) is frequency and (b) is amplitude

B) (a) is amplitude and (b) is wavelength

C) (a) is amplitude and (b) is frequency

D) (a) is wavelength and (b) is amplitude

E) (a) is wavelength and (b) is frequency

Q18. Which gas law states that pressure is inversely proportional to volume?

A) Avogadro

B) Boyle

C) Charles

D) Gay Lussac

E) Ideal

Q19. According to the ideal gas equation, volume should be equal to:

A) $\frac{nRT}{p}$

$pV = nRT$

B) $\frac{p}{nRT}$

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

C) $pnRT$

D) $\frac{pn}{RT}$

E) $\frac{RT}{pn}$

Q20. What color of visible light has the **shortest** wavelength?

A) Red

B) Green

C) Blue

D) Violet

E) Yellow

R O Y G B I V

$\lambda \longleftarrow$

$\longrightarrow \nu$

Each problem in this section (short answer) is worth 10 points ! Show all work to receive credit. Use dimensional analysis as needed and report answers with correct significant figures and the appropriate units.

Q21. When $Ca(HCO_3)_2(s)$ is added to an excess of HCl(aq), 34.0 L of gas is formed at a temperature of 22 °C and a pressure of 1.30 atm. What mass of $Ca(HCO_3)_2$ must have been used?

$$\mathbf{Ca(HCO_3)_2(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + 2H_2O(l) + \boxed{2CO_2(g)}}$$

$pV = nRT$, $V = \frac{nRT}{P}$ $\rightarrow$ $n = \frac{pV}{RT} = \frac{1.30\text{ atm} \times 34.0\text{ L}}{0.08206 \frac{\text{atm}\cdot\text{L}}{\text{mol}\cdot\text{K}} \times 295\text{K}} = 1.83\text{ mol gas}$

$1.83\text{ mol } CO_2 \times \frac{1\text{ mol } Ca(HCO_3)_2}{2\text{ mol } CO_2} \times \frac{162.12\text{ g } Ca(HCO_3)_2}{1\text{ mol } Ca(HCO_3)_2} = 148\text{ g } Ca(HCO_3)_2$

Q22. The combination of coke and steam produces a mixture called coal gas. This can be used be used as a fuel or as a starting material for other reactions. If we assume coke can be represented by graphite, the equation for the production of coal gas is:

$$\mathbf{2\ C(graphite, s) + 2\ H_2O(g) \rightarrow CH_4(g) + CO_2(g)}$$

Calculate the enthalpy change (ΔH) for this reaction given the following data:

1)	$2\times($C(graphite, s) $+ H_2O(g) \rightarrow CO(g) + H_2(g)$	$\Delta H = 131.3$ kJ/mol)
2)	$1\times(CO(g) + H_2O(g) \rightarrow CO_2(g) + H_2(g)$	$\Delta H = -41.2$/mol)
3)	$(CH_4(g) + H_2O(g) \rightarrow 3H_2(g) + CO(g)$	$\Delta H = 206.1$ kJ/mol) rev

1) $2C + 2H_2O \rightarrow \cancel{2CO} + \cancel{2H_2}$; $\Delta H = 262.6$ kJ/mol

2) $\cancel{CO} + \cancel{H_2O} \rightarrow CO_2 + \cancel{H_2}$; $\Delta H = -41.2$ kJ/mol

3) $\cancel{3H_2} + \cancel{CO} \rightarrow CH_4 + \cancel{H_2O}$; $\Delta H = -206.1$ kJ/mol

+

$2C + 2H_2O \rightarrow CH_4 + CO_2$; $\Delta H \sim +15.3$ kJ/mol

Q23. The combustion of propane, $C_3H_8(g)$, generates an abundance of heat! Using the following standard heats of formation, calculate ΔH^o_{rxn}

$$C_3H_8(g) + 5O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(g)$$

Substance	ΔH_f^o (kJ/mol)
$C_3H_8(g)$	–103.9
$H_2O(g)$	–241.8
$CO_2(g)$	–393.5

A) Calculate ΔH_{rxn}^o $= \sum n \cdot \Delta H_f^\circ (P) - (R)$

$= \left[3 \times \Delta H_f^\circ (CO_2) + 4 \times \Delta H_f^\circ (H_2O)\right] - \left[1 \times \Delta H_f^\circ (C_3H_8) + 5 \times \cancel{\Delta H_f^\circ (O_2)}\right]$ 0

$= \left[3 \times -393.5 \frac{kJ}{mol} + 4 \times -241.8 \frac{kJ}{mol}\right] - \left[1 \times -103.9\ kJ/mol\right]$

$= -2043.8\ kJ/mol$

B) How many moles of $H_2O(g)$ are produced when 1200 kJ of heat is produced?

$$-1200\ kJ \times \frac{4\ mol\ H_2O}{-2043.8\ kJ} = 2.3\ mol\ H_2O$$

C) What mass of propane needs to be burned to generate 4400 kJ of heat?

$$-4400\ kJ \times \frac{1\ mol\ C_3H_8}{-2043.8\ kJ} \times \frac{44.09\ g\ C_3H_8}{1\ mol\ C_3H_8} = 94.9\ g\ C_3H_8$$

Q24. 80.0 mL of pure water at 90.0ºC is mixed with 50.0 mL of pure water at 30.0ºC. What is the final temperature of the mixture? Note: the specific heat of water is 4.184 J/g·°C. The density of water is 1.00 g/mL. Assume an isolated system.

$$q_{hot} + q_{cold} = 0$$

$$q_{cold} = -q_{hot}$$

$$m_c S_c \Delta t_c = -m_h S_h \Delta t_h$$

$$m_c \Delta t_c = -m_h \Delta t_h \quad \text{(since } S_c = S_h = \text{water!)}$$

$$50.0g \times (t_F - 30.0°C) = -80.0g \times (t_F - 90.0°C) \quad (d \approx 1\,g/mL \rightarrow m(g) \approx V(mL))$$

$$\rightarrow 50.0g \times t_F - 1500 g\cdot°C = -80.0g\, t_F + 7200 g\cdot°C$$

$$\rightarrow 130.0g \times t_F = 8700.\,g\cdot°C$$

$$\rightarrow t_F = \frac{8700\,g\cdot°C}{130.0g} = \boxed{66.9°C}$$

check! $m_c S_c \Delta t_c \stackrel{?}{=} -m_h \cdot S_h \cdot \Delta t_h$

$$50.0g \times 4.184 \frac{J}{g\cdot°C} \times (66.9°C - 30.0°C) \stackrel{?}{=} -80.0g \times 4.184 \frac{J}{g\cdot°C} \times (66.9°C - 90.0°C)$$

$$+7719.48 J \stackrel{?}{=} +7732.032 J$$

close enough! :)

Q25. Fill in the blanks:

Visible light is a part of the electromagnetic (EM) spectrum with wavelengths between 400 nm and 700 nm. The speed of light is approximately equal to 3.00×10^8 m/s. The number of times that the wave oscillates in a second is known as its frequency.

Although light behaves as a wave, it sometimes behaves as a particle which is commonly known as a(n) photon. The energy of this can be calculated using the equation, $E = h\nu$, where "*h*" is called the Planck's constant, and the symbol ν represents its frequency.

Light with a wavelength just smaller than visible light is called ultraviolet (UV), whereas light with a wavelength just larger than visible light is called infrared (IR).

In general, light with a small wavelength has more energy.

3 Point Bonus Question

Red light from a helium-neon laser has a wavelength of 632.8 nm. Calculate the frequency of this red light.

$$c = \nu\lambda \rightarrow \nu = \frac{c}{\lambda} = \frac{3.00 \times 10^8 \text{ m/s}}{632.8 \times 10^{-9} \text{ m}}$$

$$= 4.74 \times 10^{14} \text{ Hz} \left(\text{or } \frac{1}{s} \text{ or } s^{-1} \right)$$

Useful Information

$$1\ \text{atm} = 760\ \text{mmHg} = 101325\ \text{Pa}$$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$P_i = X_iP_T \ \&\ P_T = X_AP_A + X_BP_B + \ldots$$

$d = PM / RT$ & $M = dRT/P$ $u_{rms} = \sqrt{3RT/M}$ $r_1/r_2 = \sqrt{M_2/M_1}$

$q = m \cdot s \cdot \Delta t$ $q = C \cdot \Delta t$

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

$c = \nu \cdot \lambda$ $E = h \cdot \nu = h \cdot c / \lambda$

$c = 3.00 \times 10^8$ m/s $h = 6.626 \times 10^{-34}$ J·s

$$N_A = 6.022 \times 10^{23}$$