CHEM 3530 - Exam 1 – February 10, 2017

Constants and Conversion Factors

$N_A = 6.02 \times 10^{23}$ mol^{-1}

R = 8.31 J/mol-K = 8.31 kPa-L/mol-K

1 bar = 100 kPa

1 kPa = 7.50 torr

1 J = 1 kPa-L

Molar Masses

C_4H_{10} - 58.	O_2 - 32	He - 4.	C_2H_4 - 28.
CH_4 - 16.	C_3H_8 - 44.	CO_2 - 44.	H_2O - 18.
C_8H_{18} - 114.	C_2H_6 - 30.	SO_2 - 64.1	

Solutions

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(88) **PART I. MULTIPLE CHOICE (Circle the ONE correct answer)**

1. A 45 gram sample of butane, $C_4H_{10}(g)$, contains how many carbon atoms?

   (A) 1.1×10^{23} (B) 4.7×10^{23} (C) 1.9×10^{24} (D) 1.1×10^{26}

2. The pressure of a sample of $O_2(g)$ is 150 torr at 200 °C in a 10 L container. What is the pressure of this gas at 50 °C in a 2 L container?

   (A) 1100 torr (B) 510 torr (C) 190 torr (D) 20 torr

3. A sample of a gas is initially at 300 torr and 20 °C. If the pressure on the gas is increased to 500 torr at constant volume, what is the final temperature of the gas (**in °C**)?

   (A) 33 °C (B) -97 °C (C) 488 °C (D) 215 °C

4. A sample of a gas has a volume of 1.5 L at a pressure of 600 torr and temperature of 50 °C. The number of molecules in the sample is:

   (A) 2.7×10^{22} (B) 4.3×10^{22} (C) 1.7×10^{23}

   (D) Cannot be determined without the gas's Molar Mass

5. What is the Molar Mass of a gas with a density of 1.40 g/L at a pressure of 400 torr and temperature of 100 °C ?

   (A) 22 g/mol (B) 58 g/mol (C) 81 g/mol

   (D) Cannot be determined without the volume of the container

6. A container has a gaseous mixture of 16 g of $O_2(g)$ and 10 g of He(g). The total pressure of the mixture is 12 bar. What is the partial pressure of He in the mixture?

   (A) 4.6 bar (B) 10 bar (C) 2 bar

   (D) cannot be determined without the container's volume and temperature

7. The RMS average speed of $CH_4(g)$ molecules at 200 °C is 860 m/s. What is the RMS average speed of $CH_4(g)$ molecules at 1000 °C

   (A) 520 m/s (B) 1920 m/s (C) 2310 m/s (D) 1410 m/s

8. Consider the three gases (all at 1 bar pressure): C_3H_8 at 60 °C, He at 60 °C, CH_4 at 30 °C. Of these three gases, He has the lowest density and CH_4 has the lowest molar kinetic energy.

   (A) CH_4 , He (B) He , C_3H_8 (C) He , He (D) He , CH_4

9. The rate of effusion of $C_2H_6(g)$ through a pinhole is 18.0 mol/hr. What is the rate of effusion of $SO_2(g)$ through a pinhole under the same conditions?

(A) 8.4 mol/hr (B) 12.3 mol/hr (C) 26.3 mol/hr (D) 38.5 mol/hr

10. A sample of $CO_2(g)$ effuses through a pinhole in 120 s. The same amount of an unknown gas effuses through the pinhole in 160 s. The Molar Mass of the unknown gas is

(A) 78 g/mol (B) 59 g/mol (C) 51 g/mol (D) 25 g/mol

11. The compressibility factor, Z, of a gas is defined as $Z = PV_m/RT$. One mole of a real gas at a temperature of 400 K and pressure of 100 bar has a volume of 230 mL. Therefore, _____ and _____ forces predominate in the gas.

(A) Z<1,repulsive (B) Z<1,attractive (C) Z>1,repulsive (D) Z>1,attractive

12. The **constant volume** Molar heat capacity of water vapor, $H_2O(g)$, is 25.3 J/mol-K. When 7.0 kJ of heat is removed at **constant volume** from 90 grams of water vapor initially at 180 °C, the final temperature is

(A) 125 °C (B) 235 °C (C) 147 °C (D) 55 °C

13. When 5.0 kJ of heat is added at **constant pressure** to a sample of 56 grams of $C_2H_4(g)$ originally at 200 °C, the final temperature of the gas is 257 °C. Therefore, the **constant pressure** and **constant volume** molar heat capacities of $C_2H_4(g)$ are approximately _____ J/mol-K and _____ J/mol-K.

(A) 35.6 , 43.9 (B) 27.4 , 19.1 (C) 43.9 , 52.2 (D) 43.9 , 35.6

14. For a process in which the internal energy change of a gas is **negative**, which of the following processes is/are possible?

(i) the gas is compressed and cooled
(ii) the gas is compressed and heated
(iii) the gas is expanded and heated

(A) i only (B) ii only (C) i and iii (D) ii and iii

15. When a gas is expanded reversibly and adiabatically,

(A) $w<0$, $\Delta U>0$ (B) $w<0$, $\Delta U=0$ (C) $w>0$, $\Delta U>0$ (D) $w<0$, $\Delta U<0$

16. What are w and ΔU when 3. moles of a gas is compressed isothermally and reversibly from 30 L to 2 L at 50 °C?

(A) w= +21.8 kJ and ΔU= 0 (B) w= -21.8 kJ and ΔU=0

(C) w= +21.8 kJ and ΔU= -21.8 kJ (D) w=0 and ΔU= +21.8 kJ

17. When a gas expands under a constant pressure of 0.50 bar from 2 L to 10 L and at the same time absorbs 250 J of heat, the internal energy change, ΔU, is

(A) +650 J (B) +246 J (C) -150 J (D) -650 J

18. Solid tungsten, will react with gaseous carbon monoxide to form solid tungsten hexacarbonyl, according to the reaction: $W(s) + 6\ CO(g) \rightarrow W(CO)_6(s)$. What is the work involved when one mole of W(s) reacts with CO(g) to form one mole $W(CO)_6(s)$ at 150 °C and 1 bar pressure.?

(A) +21.1 kJ (B) +3.5 kJ (C) -21.1 kJ (D) -3.5 kJ

19. For the reaction, $C_5H_{12}(gas) + 8\ O_2(gas) \rightarrow 5\ CO_2(gas) + 6\ H_2O(liq)$, at 75 °C, the internal energy change is ΔU = -3524 kJ. What is ΔH for this reaction?

(A) -3512 kJ (B) -3518 kJ (C) -3530 kJ (D) -3536 kJ

For #20-#22: The normal boiling point of octane, C_8H_{18} is 125 °C The enthalpy of vaporization of octane, C_8H_{18}, is 41.6 kJ/mol.

20. What is the heat involved when 65 grams of octane are condensed from the gas to the liquid phase at 1 bar pressure and 125 °C?

(A) +23.7 kJ (B) -73.0 kJ (C) -23.7 kJ

(D) Cannot be determined without the constant pressure molar heat capacity.

21. What is the work involved when 65 grams of octane are condensed from the gas to the liquid phase at 1 bar pressure and 125 °C?

(A) +0.8 kJ (B) +1.9 kJ (C) -2.5 kJ (D) -1.9 kJ

22. What is ΔU when 65 grams of octane are condensed from the gas to the liquid phase at 1 bar pressure and 125 °C?

(A) +21.8 kJ (B) -32.4 kJ (C) 0 kJ (D) -21.8 kJ

PART II. ONE (1) PROBLEM FOLLOWS
You MUST show your work for credit.

$C_{p,m} = 52.6\ J/mol\text{-}K$ $C_{v,m} = C_{p,m} - R = 52.6 - 8.3$
$= 44.3\ J/mol\text{-}K$

(12) 1. The **constant pressure** molar heat capacity of ethane, $C_2H_6(g)$, is 52.6 J/mol-K. A sample of 75 grams of ethane is initially at a volume of 25 L and pressure of 7.0 bar. Calculate q, w, and ΔH, **in kJ**, when the gas is cooled reversibly at **constant volume** until the pressure is reduced to 3.0 bar.

$n = 75g \times \frac{1mol}{30g}$

$= 2.5 mol$

$P_1 = 7 bar = 700 kPa$

$V_1 = 25 L$

$T_1 = \frac{P_1 V_1}{nR} = \frac{700(25)}{2.5(8.31)}$

$= 842.4 K$

$\approx 842 K$

$P_2 = 3 bar = 300 kPa$

$V_2 = V_1 = 25 L$

$T_2 = \frac{P_2 V_2}{nR} = \frac{(300)(25)}{2.5(8.31)}$

$= 361 K$

$W = 0$ - const volume.

$q = \Delta U = n C_{v,m}(T_2 - T_1)$

$= 2.5 mol\ (44.3 J/mol\text{-}K)[361K - 842K]$

$= -53270 J \times \frac{1kJ}{1000J}$

$= \boxed{-53.3 kJ} = q$

$\Delta H = n C_{p,m}[T_2 - T_1]$

$= (2.5 mol)(52.6 J/mol\text{-}K)[361K - 842K]$

$= -63250 J \times \frac{1kJ}{1000J}$

$= \boxed{-63.3 kJ} = \Delta H$