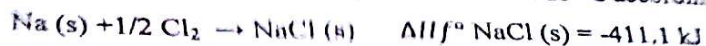


**PART I:-Multiple Choice (15 pts)**

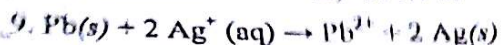
1. An engineer pumps air at 0°C into a newly designed piston-cylinder assembly. The volume measures 6.83 cm<sup>3</sup>. At what temperature (in K) will the volume be 9.75 cm<sup>3</sup>?  
A) 298 K      B) 389.9 K      C) 180 K      D) 396 K      E) None
2. Which one is false about equilibrium constant (K) and reaction quotient (Q)?  
A) If  $Q_c < K_c$ , more product forms.      C) If  $Q_c = K_c$ , there is no net change  
B) If  $Q_c > K_c$ , more reactant forms.      D) If  $Q_c < K_c$ , more reactant forms.      E) None
3. All of the following are state function except:  
A) Reaction Kinetics      B) Work      C) Internal energy  
D) A & B      E) None
4. A chemical engineer injects limestone (CaCO<sub>3</sub>) into the hot flue gas of a coal burning power plant to form lime (CaO), which scrubs SO<sub>2</sub> from the gas and forms gypsum (CaSO<sub>4</sub>·2H<sub>2</sub>O). What is K<sub>c</sub> for the following reaction, if CO<sub>2</sub> pressure is in atmospheres?  
$$\text{CaCO}_3(\text{s}) \rightleftharpoons \text{CaO}(\text{s}) + \text{CO}_2(\text{g}) \quad K_p = 2.1 \times 10^{-4} \text{ (at 1000. K)}$$
  
A)  $1.6 \times 10^{-4}$       B)  $3.6 \times 10^{-5}$       C)  $2.56 \times 10^{-6}$       D)  $2.6 \times 10^{-4}$       E) None
5. Fuel engineers use the extent of the change from CO and H<sub>2</sub>O to CO<sub>2</sub> and H<sub>2</sub> to regulate the proportions of synthetic fuel mixtures. If 0.250 mol of CO and 0.250 mol of H<sub>2</sub>O are placed in a 125-mL flask at 900 K, what is the composition of the equilibrium mixture? At this temperature, K<sub>c</sub> is 1.56 for the equation;  $\text{CO}(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}_2(\text{g}) + \text{H}_2(\text{g})$   
A) [CO] = 0.15 M, [H<sub>2</sub>O] = 1.11 M      C) [CO] = 1.11 M, [H<sub>2</sub>O] = 1.11 M  
B) [CO] = 2.15 M, [H<sub>2</sub>O] = 3.11 M      D) [CO] = 0.15 M, [H<sub>2</sub>O] = 0.15 M      E) None
6. Which one of the following increases the molecular disorder?  
A) Decomposition of calcium carbonate      B) Melting of ice at 25°C  
C) A lion chasing an antelope      D) All      E) None
7. Which of the following is true for galvanic cell?  
A) An electric current is produced by using electrical energy.  
B) Anode is positive electrode.  
C) Electrons flow towards the anode.  
D) Electrons flow through the salt bridge.      E. None

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8. What is the heat released when 4.0 L of  $\text{Cl}_2$  with density of 2.46 g/mL reacts with an excess of sodium metal to form sodium chloride at 25 °C according to the following reaction?



- A) -211.1 kJ      B) -311.1 kJ      C) -114 kJ      D) -411.1 kJ



If the equilibrium constant for the reaction above is  $2.6 \times 10^{21}$ , which of the following pair is correctly describes the standard voltage  $E^\circ$ , and the standard free energy change  $G^\circ$ , for this reaction?

- A)  $E^\circ$  and  $\Delta G^\circ$  are both positive      B)  $E^\circ$  is negative and  $\Delta G^\circ$  is positive  
C)  $E^\circ$  is positive and  $\Delta G^\circ$  is negative      D)  $E^\circ$  and  $\Delta G^\circ$  are both negative  
E)  $E^\circ$  and  $\Delta G^\circ$  are both zero

10. In electrolytic cell:

- A) System performs work on the surrounding  
B) Surrounding performs work on the system  
C) The reaction proceeds towards the equilibrium      D) A & C      E) None

11. Solution is formed in which one of the following option

- A, solute/solute interaction > solvent/solvent interaction  
B, solvent/solvent interaction > solute/solute interaction  
C, solute/solvent interaction > solvent/solvent interaction  
D, solute/solvent interaction > solute/solute interaction  
E, C & D are answers

12. Activation energy can be described as the

- A) Energy of motion.      B) Energy of the activated complex.  
C) Energy difference between the reactants and the products.  
D) Energy difference between the reactants and the activated complex.      E) None

13. Reaction rate constant can be affected by:

- A) The concentration of reacting species.      B) The temperature.  
C) The activation energy.      D) B & C      E) None

14. A gas is cooled and loses 82 J of heat, the gas contracts as it cools and the work done on the system gives 29J in exchange with the surrounding. What are the values of q, w and  $\Delta E$ ?

- A) 82 J, 29 J, 53 J      B) -82 J, 29 J, -53 J      C) 32 J, 19 J, 55 J      D) 72 J, 39 J, 53 J      E) None



15. The first order of gaseous decomposition of  $\text{N}_2\text{O}_4$  into  $\text{NO}_2$  has a rate constant of  $4.5 \times 10^3 \text{ s}^{-1}$  at  $1^\circ\text{C}$  and activation energy of  $58 \text{ kJ/mol}$ . At what temperature would the rate constant be  $10^2 \text{ s}^{-1}$ ?

- A) 80 K      B) 95 K      C) 102 K      D) 200 K      E) None

**Part II: -Short Answer Questions (15 pts)**

16. The molar heat of vaporization of ethanol  $\text{C}_2\text{H}_5\text{OH}$  is  $38.56 \text{ kJ/mol}$  at its normal boiling point  $78.1^\circ\text{C}$ . The change in entropy during the phase transition of  $68.3 \text{ g}$  of ethanol from liquid to gas at its boiling temperature is \_\_\_\_\_. (2 pts)
17. What is the effect of the following on the volume of one mole of an ideal gas? (2 pts)
- a) The pressure is reduced by a factor of 4 (at constant T)
  - b) The pressure changes from 760 torr to 202 kPa, and the temperature changes from  $37^\circ\text{C}$  to  $155 \text{ K}$ .
- 18) Choose the member with the higher entropy in each of the following pairs (2 pts)
- a) 3 mol of  $\text{O}_2(\text{g})$  or 2 mol of  $\text{O}_3(\text{g})$
  - b) 1 mol of  $\text{CF}_4(\text{g})$  or 1 mol of  $\text{CCl}_4(\text{g})$
- 19) The molar solubility for  $\text{MX}_2$  is  $1.52 \times 10^{-3} \text{ M}$ , then  $K_{\text{sp}}$  is \_\_\_\_\_. (2 pts)
- 20) A concentration cell consists of two  $\text{Cr}/\text{Cr}^{3+}$  half-cells. In half-cell A, electrode A dips into  $[\text{Cr}^{3+}] = 7.0 \times 10^{-4} \text{ M}$  electrolyte solution and in half-cell B, electrode B dips into  $[\text{Cr}^{3+}] = 2.5 \times 10^{-2} \text{ M}$  electrolyte solution. Then:
- (a) The cell potential,  $E_{\text{cell}}$  at  $298.15 \text{ K}$  \_\_\_\_\_.
  - (b) The positive electrode is \_\_\_\_\_ and the negative electrode is \_\_\_\_\_.
  - (c) Draw cell diagram, indicate direction of electron flow in the external circuit & ions flow in salt bridge and check the spontaneity of the cell. (4 pts)

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1) A first-order reaction is 38.5% complete in 500 second. (3 pts)

(a) The rate constant in per second is  $9.67 \times 10^{-4} \text{ s}^{-1}$

(b) The time required to complete 90% of the reaction is  $2382 \text{ s}$

### Part III: -Calculations (10 pts)

Show all the steps clearly and neatly.

22. Calculate  $K_c$  for the following equilibria:  $\text{CO(g)} + \text{Cl}_2(\text{g}) \rightleftharpoons \text{COCl}_2(\text{g})$ ;  $K_p = 3.9 \times 10^{-2}$  at 1000 K (3 pts)

given

$$K_p = 3.9 \times 10^{-2} \quad T = 1000 \text{ K} \quad \Delta n = -1$$

$$K_p = K_c \cdot R T^{\Delta n} \quad \text{or } K_p = K_c \cdot R T^{-1}$$

$$K_c = K_p \cdot R T$$

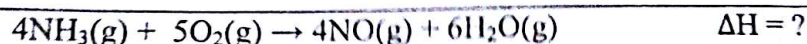
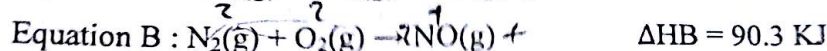
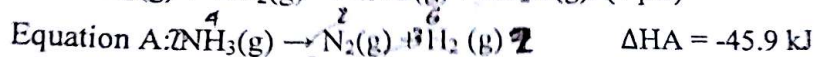
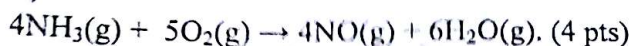
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$$\frac{K_p}{R T^{\Delta n}} = K_c \cdot R T$$

$$= 3.9 \times 10^{-2} \times 1000 \text{ K} \times 0.0821$$

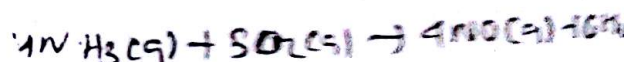
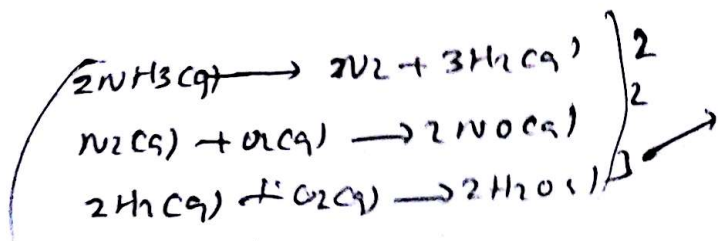
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23) Given the following reactions, calculate the heat of reaction from heats of formations



if we balance them

$$\Delta H = -636.6 \text{ kJ}$$



then

$$\Delta H_A = 2 \times -45.9 \text{ kJ} = -91.8 \text{ kJ}$$

$$\Delta H_B = 2 \times 90.3 \text{ kJ} = 180.6 \text{ kJ}$$

$$\Delta H_C = 3 \times -241.8 \text{ kJ} = -725.4 \text{ kJ}$$

$$= -91.8 \text{ kJ} + 180.6 \text{ kJ} + (-725.4 \text{ kJ})$$

$$= -636.6 \text{ kJ}$$

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24) Gaseous X atoms combine to form molecular X in the gas phase

$X(g) + X(g) \rightarrow X_2(g)$ , has the high rate constant  $7.2 \times 10^{-1} \text{ L mol}^{-1} \text{ s}^{-1}$  at  $23^\circ \text{C}$ . If the initial concentration of X was  $0.086 \text{ M}$ , calculate the concentration of X after  $2.0 \text{ min}$ . (3 pts)

$$k = 7.2 \times 10^{-1} \text{ L mol}^{-1} \text{ s}^{-1} \rightarrow \text{As it is second order}$$

$$[A]_0 = 0.086$$

$$t = 120 \text{ s}$$

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