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^3. At what temperature (in K) will the volume be 9.75 cm^3?

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 Qc < Kc, more product forms. C) If Qc = Kc, there is no net change

B) If Qc > Kc , more reactant forms. D) If Qc < Kc , 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 ($CaCO_3$) into the hot flue gas of a coal burning power plant to form lime (CaO), which scrubs SO_2 from the gas and forms gypsum ($CaSO_4 \cdot 2H_2O$). What is Kc for the following reaction, if CO_2 pressure is in atmospheres?

$CaCO_3(s) \leftrightharpoons CaO(s) + CO_2(g)$ $Kp = 2.1 \times 10^{-4}$ (at 1000. K)

A) 1.6×10^{-4} B) 3.6×10^{-5} C) 2.56×10^{-6} D) 2.6×10^{-4} E) None

____5. Fuel engineers use the extent of the change from CO and H_2O to CO_2 and H_2 to regulate the proportions of synthetic fuel mixtures. If 0.250 mol of CO and 0.250 mol of H_2O are placed in a 125-mL flask at 900 K, what is the composition of the equilibrium mixture? At this temperature, Kc is 1.56 for the equation; $CO(g) + H_2O(g) \leftrightharpoons CO_2(g) + H_2(g)$

A) [CO]= 0.15 M , $[H_2O]$ = 1.11M C) [CO]= 1.11 M , $[H_2O]$ = 1.11M

B) [CO]= 2.15 M , $[H_2O]$ = 3.11M D) [CO]= 0.15 M , $[H_2O]$ = 0.15M 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 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?

$Na\ (s) + 1/2\ Cl_2 \rightarrow NaCl\ (s)$ $\quad \Delta H f°\ NaCl\ (s) = -411.1\ kJ$

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

9. $Pb(s) + 2\ Ag^+(aq) \rightarrow Pb^{2+} + 2\ Ag(s)$

If the equilibrium constant for the reaction above is 2.6×10^{31}, which of the following pair is correctly describes the standard voltage $E°$, and the standard free energy change $G°$, for this reaction?

A) E° and ΔG° are both positive B) E° is negative and ΔG° is positive

C) E° is positive and ΔG° is negative D) E° and ΔG° are both negative

E) E° and ΔG° 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 ΔE?

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 N_2O_4 into NO_2 has a rate constant of 4.5 x 10^3 s^{-1} at 1 °C and activation energy of 58 KJ/mol. At what temperature would the rate constant be $10^2 s^{-1}$?

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 C_2H_5OH is 38.56 KJ/mol at its normal boiling point 78.1 C^0. The change in entropy during the phase transition of 68.3 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 to 760 torr to 202 kPa, and the temperature changes from 37 °C to 155 K.

18) Choose the member with the higher entropy in each of the following pairs (2 pts)

a) 3 mol of $O_2(g)$ or 2 mol of $O_3(g)$

b) 1 mol of $CF_4(g)$ or 1 mol of $CCl_4(g)$

19) The molar solubility for MX_2 is 1.52 x 10^{-3} M, then Ksp is_____(2 pts)

20) A concentration cell consists of two Cr/Cr^{3+} half-cells. In half-cell A, electrode A dips into $[Cr^{3+}]$ = 7.0 X 10^{-4} M electrolyte solution and in half-cell B, electrode B dips into $[Cr^{3+}]$ = 2.5 X 10^{-2} M electrolyte solution. Then:

(a) The cell potential, Ecell at 298.15 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)

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

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

(b) The time required to complete 90% of the reaction is 2382 s

Part III: -Calculations (10 pts)

Show all the steps clearly and neatly.

22. Calculate K_c for the following equilibria: $CO(g) + Cl_2(g) \leftrightarrows COCl_2(g)$; $K_p = 3.9 \times 10^{-2}$ at 1000 K (3 pts)

given

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

req

$K_c = ?$

$K_p = K_c \cdot RT^{\Delta n}$ $K_p = K_c \cdot RT^{\Delta n}$

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

$= 3.2019$ ← $= 3.9 \times 10^{-2} \times 1000\ K \times 0.0821$

$= 3.2019$ L atm / mol

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

$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$. (4 pts)

Equation A: $2NH_3(g) \rightarrow N_2(g) + 3H_2(g)$ $\Delta HA = -45.9$ kJ

Equation B : $N_2(g) + O_2(g) \rightarrow 2NO(g)$ $\Delta HB = 90.3$ KJ

Equation C : $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$ $\Delta HC = -241.8$ KJ

$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$ $\Delta H = ?$

1st . we balance them

Ans -636.6 KJ

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

$N_2(g) + O_2(g) \rightarrow 2NO(g)$ ×2

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ ×3

→ $4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O$

then

$\Delta HA = 2 \times -45.9$ KJ $= -91.8$ KJ + 180.6 + (−725.4)

$\Delta HB = 2 \times 90.3$ KJ

$\Delta HC = 3 \times -241.8$ KJ $= -636.6$ KJ

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 7.2×10^{-1} L $mol^{-1} s^{-1}$ at 23 °C. If the initial concentration of X was 0.086 M, calculate the concentration of X after 2.0 min. (3 pts)

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

$[A]_0 = 0.086$

$t = 120s$