**Name: Student ID:**

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**CHEM 233 Final Exam**

**Date: 29/05/1445**

**Time allowed: 2 hours**

**Physical constants & conversion factors:**

**R = 0.0821 L.atm / mol.K = 8.314 J/mol K**

**1 atm = 101.325 k Pa = 760 mmHg**

**1 atm L = 101.3 J**

**S (water) = 4.184 J/g.0C**

**QCM answers**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
|  |  |  |  |  |  |  |  |  |  |
| **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** |
|  |  |  |  |  |  |  |  |  |  |
| **21** | **22** | **23** | **24** | **25** | **26** | **27** | **28** | **29** | **30** |
|  |  |  |  |  |  |  |  |  |  |

**Part 1**

**Multiple-Choice Questions**

**(30 x 1 pt = 30 Points)**

**For each Multiple-Choice Question (MCQ), choose the correct answer and place the corresponding letter in the table of the first page:**

**1- Objects can possess energy as**

**(a) endothermic energy (b) potential energy**

**(c) electric energy (d) exothermic energy**

**---------------------------------------------------------------------------------------------------**

**2- The change in internal energy (ΔU in *kJ*) for a system that performs 300 *kJ* of work on its surroundings and loses 200 *kJ* of heat is**

**(a) 500 (b) 100**

**(c) -100 (d) -500**

**---------------------------------------------------------------------------------------------------**

**3- Of the following, which one is a state function?**

**(a) H (b) q (c) w (d) heat**

**---------------------------------------------------------------------------------------------------**

**4- Which of the following is a statement of the first law of thermodynamics?**

**(a) Ek = (1/2) mv2**

**(b) A negative ΔH corresponds to an exothermic process**

**(c) ΔU = Ufinal - Uinitial**

**(d) Energy lost by the system must be gained by the surroundings.**

**---------------------------------------------------------------------------------------------------**

**5- A chemical reaction that absorbs heat from the surroundings is said to be \_\_\_\_\_\_\_\_ and has a \_\_\_\_\_\_\_\_\_\_ ΔH at constant pressure.**

**(a) endothermic, positive (b) exothermic, negative**

**(c) exothermic, positive (d) endothermic, negative**

**---------------------------------------------------------------------------------------------------**

**6- Which of the following is an intensive property?**

**(a) the mass (b) the volume**

**(c) the molar enthalpy of formation (d) the internal energy**

**---------------------------------------------------------------------------------------------------**

**7- The combustion of butane produces heat according to the equation**

**2 C4H10(g) + 13 O2(g) --> 8 CO2(g) + 10 H2O(l) ΔH = -5314 kJ**

**How many grams of butane must be burned to release 250 kJ of heat?**

**(a) 5.5 (b) 25.1 (c) 2.3 (d) 9.5**

**---------------------------------------------------------------------------------------------------**

**8- The work obtained during an adiabatic expansion of an ideal gas is:**

**(a) greater than that obtained during an isothermal expansion of an ideal gas**

**(b) equal to that obtained during an isothermal expansion of an ideal gas**

**(c) less than that obtained during an isothermal expansion of an ideal gas**

**(d) we cannot know**

**---------------------------------------------------------------------------------------------------**

**9- A 100. mL sample of 0.200 M aqueous hydrochloric acid is added to 100. mL of 0.200 M aqueous ammonia in a calorimeter whose heat capacity (excluding any water) is 480. J/K.**

**The following reaction occurs when the two solutions are mixed.**

**HCl(aq) + NH3(aq) --> NH4Cl(aq)**

**The temperature increase is 2.34 oC. Calculate ΔH in kJ per mole of HCl reacted.**

**(a) 154 (b) 132.16 (c) 2375 (d) 95**

**---------------------------------------------------------------------------------------------------**

**10- The work obtained during an irreversible expansion of an ideal gas is:**

**(a) greater than that obtained during a reversible expansion of an ideal gas**

**(b) equal to that obtained during a reversible expansion of an ideal gas**

**(c) less than that obtained during a reversible expansion of an ideal gas**

**(d) we cannot know**

**---------------------------------------------------------------------------------------------------**

**11- Which of the reversible processes listed below are used to form a Carnot cycle?**

**(a) Isothermal, adiabatic (b) Isochoric, adiabatic**

**(c) Isobaric, adiabatic (d) Isochoric, isobaric**

**---------------------------------------------------------------------------------------------------**

**12- For the following gas-phase reaction, which of the following statements is TRUE?**

**2NO2(g) → 2NO(g) + O2(g) ΔGo = + 70.5 kJ**

**(a) The reaction is spontaneous in forward direction**

**(b) The reaction is spontaneous in backward direction**

**(c) The reaction is spontaneous in both directions**

**(d) The reaction is at equilibrium.**

**---------------------------------------------------------------------------------------------------------------------**

**13 -A reaction is spontaneous at all temperatures if**

**(a) ΔH is positive and ΔS is negative. (b) ΔH and ΔS are both negative.**

**(c) ΔH and ΔS are both positive. (d) ΔH is negative and ΔS is positive.**

**-----------------------------------------------------------------------------------------------------**

**14- A cyclic heat engine does 50 kJ of work per cycle. If the efficiency of engine is 75%, the heatabsorbed per cycle will be**

**(a) 66.7 kJ (b) 16.7 kJ (c) 60.7 kJ (d) 200 kJ**

**15- In isothermal process, 2 moles of an ideal gas expand from 1.0 L to 10.0 L. Calculate ∆S (J/K) for this process.**

**(a) +38.29 (b) 0 (c) - 40.33 (d) 56.16**

**16- For melting of a solid substance, which of the following answer is correct?**

**(a) ∆H < 0 , ∆S < 0 (b) ∆H = 0 , ∆S = 0**

**(c) ∆H > 0 , ∆S > 0 (d) ∆H > 0 , ∆S = 0**

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**17- In which of the following process, a decrease in entropy is observed?**

**(a) dissolution of salt in water (b) sublimation of naphthalene**

**(c) condensation of water (d) melting of ice**

**---------------------------------------------------------------------------------------------------------**

**18-The standard Gibbs free energy of formation ΔGᴼf is zero for**

**(a) 2H(g) (b) O(g) (c) H2(g) (d) H2O(l)**

**----------------------------------------------------------------------------------------------------------**

**19-The area of p-V diagram for a Carnot cycle represents**

**(a) Heat supplied (b) Work done**

**(c) Heat rejected (d) Temperature drop**

**--------------------------------------------------------------------------------------------------------**

**20- At equilibrium, the Gibbs free energy ΔG is:**

**(a) positive (b) negative ( c) zero (d) none of these**

**--------------------------------------------------------------------------------------------------------**

**21- The combined relation between first and second law is given by the relation:**

**(a) dU = TdS - PdV (b) dU = TdS + VdP**

**(c) dU = TdS (d) ∆S = q / T**

**---------------------------------------------------------------------------------------------------------------------**

**22- If ∆G° > 0, then K is:**

**(a) >1 and the products are favored (b) < 1 and reactant are favored**

**c) = 1 and products are favored (d) > 1 and reactant are favored**

**---------------------------------------------------------------------------------------------------------------------**

**23- Which of the following thermodynamic relation is correct**

**a) (δH/δS)v = T b) (δH/δP)s = V c) (δU/δS)p = T d) (δU/δV)s = -P**

**---------------------------------------------------------------------------------------------------------------------**

**24- Estimate the heat of reaction at 298 K for the reaction shown, given the average bond energies below.**

**Br-Br (g) + 3 F-F (g) https://www.chem.tamu.edu/class/fyp/mcquest/pics/arrw-tan.gif 2 BrF3**

|  |  |  |
| --- | --- | --- |
| **Bond** |  | **Bond Energy** |
| **Br-Br** |  | **192 kJ** |
| **F-F** |  | **158 kJ** |
| **Br-F** |  | **197 kJ** |

**(a) -516 kJ (b) -410 kJ (c) -611 kJ (d) -665 kJ**

**25-Helmholtz free energy (A) is defined as:**

**(a)A = H+ TS (b) A= H-TS (c) A=U-TS (d) A =U+TS**

**---------------------------------------------------------------------------------------------------------------------**

**26- Which of the following statements best describes the Second Law of Thermodynamics?**

1. **The internal energy of the universe is constant.**
2. **Energy can be neither created nor destroyed.**
3. **In any irreversible process ΔS system + ΔS surrounding > 0**
4. **At absolute zero, the entropy of perfect crystal is zero.**

**27- ……….. is a device for extracting work from a hot fluid**

**(a) A calorimeter (b) Heat engine. (c) Barometer (d) Thermometer**

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**28- Calculate the boiling point (Tb) of water (H2O)l  if ∆Hvap = 40.850 kJ/mole and   
∆Svap = 109.5 J/mol.K:**

**(a) 373 K (b) 50 K (c) 0 K (d) 100 K**

**29-Which of the following gases has lowest entropy at 25οC and 1 atm.**

**(a) H2 (b) C2H6 (c) C2H2  (d) CH4**

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**30- In the first stage of Carnot cycle, the entropy changes is:**

**(a) Positive (b) Negative (c) Zero (d) None of the above**

**------------------------------------------------------------------------------------------------------------------**

**Part 2 (2 x 5 pt = 10 Points)**

**Solve only two questions of the following:**

**1- When 1.5 g of benzoic acid was burned in a calorimeter containing 1000. g of water, a temperature rise of 3.5 oC was observed.**

**What is the heat capacity of the bomb calorimeter (in J/ oC), excluding the water? The heat of combustion of benzoic acid is -26.42 kJ/g.**

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**2- A possible reaction for converting methanol to ethanol is:**

**CO (g) + 2 H2 (g) + CH3OH (g) ––––> C2H5OH (g) + H2O (g)**

**Use the table of thermodynamic data (at 25°C) below to calculate: ΔH° , ΔS°, ΔG°.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Substance and State** | **ΔHfo (kJ/mol)** |  | **So (J/mol.K)** |
| **CO(g)** | **-110.5** |  | **198** |
| **H2(g)** | **0** |  | **131** |
| **CH3OH(g)** | **-201.2** |  | **237.6** |
| **C2H5OH(g)** | **–235.1** |  | **282.6** |
| **H2O(g)** | **-242** |  | **189** |

**------------------------------------------------------------------------------------------------------------------**

**3- The reaction 2 Al3Cl9 (g) → 3 Al2Cl6 (g)**

**has an equilibrium constant of 8.8x103 at 443K and a ΔHr° = 39.8 kJmol-1 at 443K. Estimate the equilibrium constant at a temperature of 600K.**

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