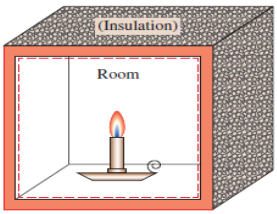
<u>Question One</u>: Choose the most correct answer [20 marks, a mark each]

1- If an energy transfer between a closed system and its surroundings is not heat, it must be -------.
(A) work (C) mechanical energy
(B) thermal energy (D) mass, E_{mass}

2- Processes occurring with no change in pressure is termed ----------.
(A) isobaric (B) isothermal (C) isochoric (D) adiabatic

3- The term "steady" is always used in thermodynamic processes to indicate no change with ----------.
(A) time (B) location (C) temperature (D) All of them

4- A candle is burnt in a well-insulated room. Taking the only air in the room as the system, the following relations can account for the heat transfer during this burning process (Q) and the change in the internal energy of the system ΔU.



(A) Q = +ve, ΔU = +ve (C) Q = 0, ΔU = 0
(B) Q = –ve, ΔU = +ve (D) Q = +ve, ΔU = 0

5- For a mono-atomic ideal gas, the molar heat capacity, c_p equals ---------.
(A) $\frac{5}{2}R$ (B) $\frac{3}{2}$R (C)) $\frac{5}{2}$ (D) R

6- If the volume of a gas is reduced to half of its original value, the specific heat capacity, c_P, of the gas is expected to become ---------.
(A) 0.5 c_P (B) c_P (C) 2.0 c_P (D) 4.0 c_P

7- Joule-Thomson effect is based upon the ----------.
(A) sudden compression of gases (C) cooling of gases
(B) sudden expansion of gases (D) heating of gases

8- Enthalpy of sublimation, $\Delta H_{sublimation}$, of a substance is equal to ----------.
(A) $\Delta H_{fusion} - \Delta H_{vaporization}$ (C) $2 \times \Delta H_{vaporization}$
(B) $\Delta H_{fusion} + \Delta H_{vaporization}$ (D) $\Delta H_{vaporization}$

9- The entropy of any pure perfectly crystalline solid is --------- at the absolute zero (0 K).
(A) positive (C) negative
(B) ZERO (D) None of them

10- "The entropy of vaporization is almost the same (88 J K^{-1} mol^{-1}) for various kinds of liquids at their standard boiling points" is a statement for --------- rule.

(A) Richard's (B) Trouton's (C) Clausius (D) None of them

11- The unit of molar entropy is similar to that of the ----------.

(A) specific heat capacity (C) universal gas constant
(B) heat energy (D) None of them

12- If 36 kJ of energy was supplied to water as heat through an electric heater immersed in an open beaker of water, the change in enthalpy of water will be ---------- kJ.

(A) >36 (B) <36 (C) 36 (D) None of them

13- During the complete combustion of one mole of butane, 2658 kJ of heat is released. The thermochemical reaction for the above change is ----------.

(A) $2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O\ (l)$ $\Delta_c H = -2658$ kJ
(B) $C_4H_{10}(g) + 13O_2(g) \rightarrow 4CO_2(g) + 10H_2O\ (l)$ $\Delta_c H = -2658$ kJ mol^{-1}
(C) $C_4H_{10}(g) + \frac{13}{2}O_2(g) \rightarrow 4CO_2(g) + 5H_2O\ (l)$ $\Delta_c H = -2658$ kJ mol^{-1}
(D) $C_4H_{10}(g) + \frac{13}{2}O_2(g) \rightarrow 4CO_2(g) + 5H_2O\ (l)(l)$ $\Delta_c H = +2658$ kJ mol^{-1}

14- In an adiabatic expansion process against vacuum, which of the following relations are valid?

(A) $Q = 0$, $\Delta T \neq 0$, $W = 0$ (C) $Q = 0$, $\Delta T = 0$, $W = 0$
(B) $Q \neq 0$, $\Delta T = 0$, $W = 0$ (D) $Q = 0$, $\Delta T < 0$, $W \neq 0$

15- In view of the entropy change that can be calculated using the expression $\Delta S = \frac{Q_{rev}}{T}$, freezing of water in a glass beaker (system) can be considered a typical example for --------.

(A) ΔS (system) decreases but ΔS (surroundings) remains the same.
(B) ΔS (system) increases but ΔS (surroundings) decreases.
(C) ΔS (system) decreases but ΔS (surroundings) increases.
(D) ΔS (system) decreases and ΔS (surroundings) also decreases.

16- Isolated systems exchange energy with its surrounding as ----------.

(A) heat (B) work (C) mass (D) None of them

17- Which of the following features is <u>not True</u> about reversible processes?

(A) A slow change during investigations.
(B) Driving force is infinitesimally greater than the opposing force and vice versa.
(C) Process may take place in either direction.
(D) Minimum work is obtained.

18- Which of the following statements agrees with the second law of thermodynamics?

(A) Naturally occurring processes proceed spontaneously in the directions which leads to equilibrium.
(B) Entropy of isolated systems increases gradually in spontaneous processes until reaching equilibrium then remains constant
(C) All natural processes are unidirectional.
(D) All of them

19- A criterion of <u>irreversibility</u> for a change in a closed system in absence of any additional non-expansion work is ----------.

(A) $(dS)_{V,U} > 0$
(B) $(dG)_{T,P} < 0$
(C) $(dH)_{P,S} < 0$
(D) All of them

20- The equilibrium constant of reversible reactions depends on ----------.

(A) reactants' activities
(B) products' activities
(C) reactants and products' activities
(D) standard free energy change

Question Two: State True (√) or False (×) [20 marks, a mark each]

21- A closed system cannot interact with its surroundings. ( )

22- Work is a state function ( )

23- For a constant-volume process in a closed system, $\Delta H = \Delta U$. ( )

24- Adiabatic processes proceed with no change in temperature. ( )

25- Carnot cycle is also always preferred as it turns out with Zero work. ( )

26- If two bodies (X & Y) are in thermal equilibrium with a third body (Z), they (X & Y) are not necessarily to be in thermal equilibrium with each other. ( )

27- If two bodies of different temperatures are brought in contact, the rate of heat transfer between them will be inversely proportional to the difference in their temperatures, ΔT. ( )

28- The PV representations of isothermal and adiabatic expansions from the same initial and final states always show the isothermal line steeper (drops off to a lower pressure) than the adiabatic line. ( )

29- Heat is a more valuable form of energy than work since 100 percent of heat can be converted to work, but only a fraction of work can be converted to heat. ( )

30- Based on the Clapeyron's equation, and unlike all liquid/solid transformations, the melting point of ice increases with increasing pressure. ( )

31- Density is an intensive property ( )

32- For a cyclic process, the final state of the system is the same as the initial state. ( )

33- $\Delta T = 0$ for every isothermal process. ( )

34- Decreasing the temperature of the cold reservoir in a heat engine operating in a Carnot cycle increases the engine's efficiency. ( )

35- The efficiency of an irreversible heat engine is always less than the efficiency of a reversible one operating between the same two reservoirs. ( )

36- A process proceeding in a quasi-static manner ensures that the system remains, infinitesimally, close to an equilibrium state at all times. ( )

37- For liquids and solids exposed to an open atmosphere, one can simply assume the relationship, $\Delta H = \Delta$U for a change they may encounter. ( )

38- The standard enthalpy of formation of gaseous O_2 is zero. ( )

39- According to Joule experiment, the internal energy of an ideal gas is constant if the gas is expanded isothermally. ( )

40 Throttling devices (valves) in refrigerators are designed maintain the energy conservation with no change in enthalpy. ( )

<u>Question Three</u>: Solve the following problem [5 marks]

The reaction $\frac{1}{2} O_2 (g) + H_2 (g) \rightarrow H_2O (l)$

is used in fuel cells to produce an electrical current. The reaction can also be carried out by direct combustion. Knowing the following constants,
molar entropies (J $mol^{-1} K^{-1}$): O_2 (g) = 205.0; H_2 (g) = 130.6; H_2O (l) = 70.0,
$\Delta H_f°$ of H_2O (l) = –285.9 kJ mol^{-1},

i. calculate the amount of heat released when the reaction takes place by direct combustion? (1 mark)

ii. calculate the amount of electrical work the same reaction can perform when carried out in a fuel cell at 298K under reversible conditions? (2 marks)

iii. calculate the amount of heat released in case of fuel cell reactors under the same previous conditions. (2 marks)

Question Four: Solve the following problem [5 marks]

i- Calculate the total work done by 1 mol of an ideal gas if it expands isothermally and reversibly at 25°C from 1 L at 10 atm to 10 L? (3 marks)

ii- Calculate also the entropy change accompanying the same abovementioned expansion? (2 marks)

<u>Question Five</u>: Solve the following problem [5 marks]

A Carnot heat engine receives 500 kJ of heat per cycle from a high temperature source at 652°C and rejects heat to a low-temperature sink at 30°C.

i- Determine the thermal efficiency of this Carnot engine? (3 marks)
ii- Determine the amount of heat rejected to the sink per cycle? (2 marks)

Question Six: Solve the following problem [5 marks]

The densities of ice and liquid water are 0.916 and 0.9999 g cm^{-3}, respectively, at the melting point and 1 atm. Utilizing the following equation,

$$H_2O_{(S)} \rightleftharpoons H_2O_{(l)} \qquad \Delta H_m = 6022\, J\, mol^{-1} at\ 0^o C$$

i- calculate the rate ($^oC\ atm^{-1}$) of changing the melting point with pressure? (3 marks)

ii- calculate the pressure required to decrease the melting point to –3.0°C, assuming that ΔH and ΔV are independent of T? (2 marks)

[END of Questions] GOOD LUCK