VEER SURENDRA SAI UNIVERSITY OF TECHNOLOGY, BURLA
DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING
SESSION 2015-16 (ODD SEMESTER)

Total Pages—6

(Set-Q_1)

B.Tech-3rd (M & M)

Metall. Thermodynamics and Kinetics

Full Marks : 70

Time : 3 hours

Q. No. 1 is compulsory and answer any **five** from the rest

The figures in the right-hand margin indicate marks

All parts of a question should be answered at one place

1. Answer *all* questions : 2 × 10

(*a*) State Raoult's law of ideal solution.

(*b*) Calculate the entropy increase when one mole of ice melts water at 0 °C.
Given : $\Delta H = 6{\cdot}02$ kJ mol^{-1} (latent heat of fusion of water).

(*c*) Differentiate between intensive and extensive properties.

(*d*) State the zeroth law of thermodynamics.

(*Turn Over*)

(*e*) State Gibb's phase rule for metallurgical system for condensed phase.

(*f*) Differentiate between reversible and irreversible process.

(*g*) State the different postulates of statistical thermodynamics.

(*h*) Define activation energy of a reaction.

(*i*) Define state function. Provide two examples of state function.

(*j*) Differentiate among open, closed and isolated system with suitable examples.

2. (*a*) Prove that :

$$C_p - C_v = R$$

For an ideal gas under isothermal condition and constant pressure

where,

C_p is heat capacity at constant pressure, C_v is heat capacity at constant volume, R is universal gas constant. 5

(*b*) Prove that for an ideal gas, under isothermal condition. 5

$$q = RT \ln(V_f / V_i)$$

where,

V_f is the final volume of the system,

V_i is the initial volume of the system,

q is the heat supplied to the system

3. (*a*) State Hess's law. Explain the law with requisite illustration. 5

(*b*) Calculate the enthalpy of formation of WC from the following data at 25 °C : 5

(*i*) $WC + 2\frac{1}{2}O_2 = WO + CO_2$

$\Delta H^\circ = -285800$ cal/gmol

(*ii*) $C + O_2 = CO_2$

$\Delta H^\circ = -195700$ cal/gmol

(*iii*) $W + 1\frac{1}{2}O_2 = WO_3$

$\Delta H^\circ = -195700$ cal/gmol

4. (*a*) "The entropy of a system in isolation can never decrease." Give a mathematical explanation to above statement. 6

(*b*) Calculate the entropy change for the reaction.

$$Fe_2O_3 + 3C = 2Fe + CO$$

At 298 K. Given the standard values of the entropy is at 298 K for various compounds are : 4

Substance	Values of entropy
Fe_2O_3	21·4 cal/°C/mol
C	49·5 cal/°C/mol
Fe	32·63 cal/°C/mol
CO	47·3 cal/°C/mol

5. (*a*) (*i*) Derive the Gibb's-Helmohltz equation for free energy. 4

(*ii*) Derive all the Maxwell's relations for a given system. 3

(*b*) Vapour pressure of liquid zinc above melting point of 420 °C is given by :

$$\log(P_{Zn}) = \frac{6400}{T} + 5{\cdot}5$$

The heat of fusion of Zn is 1600 cal/g atom for above the melting point and it is 1400 cal/g atom below its melting point. Derive a formula for vapour pressure over solid zinc below its melting point. 3

6. (*a*) (*i*) State Sievert's law. 2

(*ii*) Molten alloy steel was found to contain 10 ppm hydrogen when inside the furnace where the ambient partial pressure of hydrogen was 0·2 atm. The steel must contain only 1 ppm before it solidifies. To what vacuum pressure it must be exposed before casting. 3

(*b*) Prove that δq is not perfectly differentiable but $(\delta q/T)$ is perfectly differentiable. 5

7. (*a*) With the help of Ellingham diagram, comment on carbothermic reduction of metal oxide. 5

(*b*) The free energy of the reaction :

$$<CaCO_3> = <CaO> + \{CO_2\}$$

$$\Delta G = 40250 - 34{\cdot}4\,T \text{ cal/gmole}$$

What is the highest temperature at which the reaction will not occur in open atmosphere. 5

8. Write short notes on any *four* : $2\frac{1}{2} \times 4$

(*i*) Activated complex theory

(*ii*) Chemical potential

(*iii*) Nernst equation

(*iv*) Clausius-Clapyeron equation

(*v*) Henry's law.