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National Institute of Technology, Durgapur

B.Tech, Mid-Term Examination, odd semester, 2018-19

Metallurgical Thermodynamics & Kinetics

MMC-301

Full Marks: 30 **Time: Two hours**

***Instructions**: Answer of any question should be written sequentially.*
*Answer **Question no. 1 and any two** from the rest.*

1. Answer all the questions. (10×1=10)

(a) Calculate the standard enthalpy change for the following reaction at 1523 K.

$Cu_2S\ (s) + 2\ Cu_2O\ (s) = 6\ Cu\ (l) + SO_2\ (g)$

Given the values of standard enthalpy changes of formation at 1523K as follows:

	$Cu_2S\ (s)$	$Cu_2O\ (s)$	$Cu\ (l)$	$SO_2\ (g)$
$\Delta H^0_{f,1523}$ (kJ/mol)	–86.7	–176.4	0	–278.4

(b) Calculate change of free energy for the following reduction reaction at 500 K:

$CuO(s) + H_2\ (g) = Cu\ (s) + H_2O\ (g)$

Given: $\Delta H^0_{500} = -87\ kJ/mol$, $\Delta S^0_{500} = 47\ J/K/mol$

(c) What do you mean by 'order of a reaction'?

(d) Iron melts at 1536°C at 1 atm pressure, and its heat of fusion is 13.81 kJ/mol. Calculate the change of entropy at melting point of iron.

(e) Define 'relaxation time' in terms of fraction transformed for a second order homogeneous type reaction involving a single reactant.

(f) Atomic weight of Cu 63.546, what is the molar volume of Cu 20°C? Where density of copper is 8.96 g/cm^3.

(g) Name two direct method and two indirect method for studying experimentally the kinetics of solid state phase transformation.

(h) Calculate the coefficient of thermal expansion α for an ideal gas at 273 K.

(i) Calculate the ratio of oxygen to acetylene for complete combustion of acetylene.

(j) Calculate the standard entropy change for the following reaction at 25°C:

$Cr_2O_3\ (s) + 3C\ (s) = 2Cr\ (s) + 3CO\ (g)$

Given:

	$Cr_2O_3\ (s)$	$C\ (s)$	$Cr\ (s$	$CO\ (g)$
S^0_{298} (J/K/mol)	81.17	5.69	23.76	197.90

2.(a) Prove that the efficiency of the Carnot cycle is given by $\eta = 1 - \frac{T_C}{T_H}$ Where T_C = Temperature of cold reservoir and T_H = Temperature of hot reservoir. (6)

(b) Prove that $C_P - C_V = \left(\frac{\partial V}{\partial T}\right)_P \left[\left(\frac{\partial E}{\partial V}\right)_T + P\right]$ (4)

3. (a) Using the empirical rate equation discuss the kinetics of an autocatalytic reaction which is first order with respect to a reactant and a product (which serves as catalyst). (6)

(b) Describe an experimental method for the evaluation of activation energy of an autocatalytic reaction. (4)

4. (a) Calculate enthalpy change ($\Delta H^0_{2000} - \Delta H^0_{298}$) in heating 1 mole of iron from 298 K to

2000 K from the following data:

Transformation reaction	Temperature (K)	Specific heat (C_P) ($J\,mol^{-1}K^{-1}$)	Enthalpy change (ΔH) ($J\,mol^{-1}$)
$Fe_\alpha \rightarrow Fe_\beta$	1033	$Fe_\alpha = 17.49 + 24.769 \times 10^{-3}\,T$	+5105
$Fe_\beta \rightarrow Fe_\gamma$	1187	$Fe_\beta = 37.66$	+ 670
$Fe_\gamma \rightarrow Fe_\delta$	1665	$Fe_\gamma = 7.70 + 19.5 \times 10^{-3}\,T$	+ 837
$Fe_\delta \rightarrow Fe_{liq}$	1809	$Fe_\delta = 28.284 + 7.53 \times 10^{-3}\,T$	+ 13807
		$Fe_{liq} = 35.4 + 3.74 \times 10^{-3}\,T$	

(5)

(b) Is the reaction $Fe_2O_3\ (s) + 3H_2\ (g) = 2Fe\ (s) + 3\ H_2O\ (l)$, feasible at 25°C and 1 atm pressure? (2.5)

Given: $\Delta H^0_{298,H_2O(l)} = -241.789\ kJ/mol$, $\Delta H^0_{298,Fe_2O_3(s)} = -882.156\ kJ/mol$, $S^0_{298,H_2O(l)} = 188.7\ J/K/mol$, $S^0_{298,Fe(S)} = 27.15\ J/K/mol$, $S^0_{298,H_2(g)} = 130.58\ J/K/mol$, $S^0_{298,Fe_2O_3(s)} = 89.95\ J/K/mol$

(c) Show that for 1 mole of a van der Waals gas undergoing an isothermal process, (2.5)

$$\Delta F = -RT \ln\left[\frac{(V_2 - b)}{(V_1 - b)}\right] - a\left[\frac{1}{V_2} - \frac{1}{V_1}\right]$$

And $$\Delta G = -RT \ln\left[\frac{(V_2 - b)}{(V_1 - b)}\right] - 2a\left[\frac{1}{V_2} - \frac{1}{V_1}\right] + bRT\left[\frac{1}{(V_2 - b)} - \frac{1}{(V_1 - b)}\right]$$

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B.Tech - 3rd Semester, Mid- Semester Examination, 2017-2018
Sub.- Introduction to Metallurgy and Materials (MMC- 302)
Total marks – 30 Time: 2 hrs

1. (a) How are orbital angular momentum and the component of orbital angular momentum in the direction of applied magnetic field quantized?
(b) How do you get spatial orientation of different orbital?

(3+2)

2. How is the situation for a vibrating string clamped at both ends translated to understand behaviour of microparticle?

(5)

3. Considering two-atom system, derive an expression of potential energy for ionic bonding and accordingly, find out equilibrium separation.

(5)

4. Draw a schematic diagram of a FCC unit cell. Calculate its packing efficiency.

(3+3)

5. Draw the unit cell of Zinc Blende. Calculate the effective number of Zn and S ion. What are the coordination numbers of Zn and S ion?

(4+3+2)

Signature of the question setter:

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National Institute of Technology, Durgapur
Department of Metallurgical and Materials Engineering
Mid-Semester Examination
Sub: **Non-Ferrous Metallurgy**

Full Marks -30 Time : 2 hour Sub Code –MMC-303

Answer all questions . All questions carry equal marks. Give sketches wherever necessary.

1) With a neat sketch show all the regions in a working ball mill. How does crushing takes place in a ball mill ? Find out the limiting RPM of a ball mill.
2) What is agglomeration. of fines? Explain the function of pelletisation in extractive metallurgy. What are the factors that affects the strength of sinter formed in a machine?
3) What is classification of minerals ? Explain the process of cyclone separator. Name any other equipment for separation of particles based on size.
4) How does pyro metallurgy is different from hydrometallurgy ? Does the comminution of minerals is necessary for hydrometallurgy? If so give reasons? Comment on extraction of metal from an ore by different routes of extraction process.
5) Explain with a neat sketch the separation process in magnetic separator and electro separator. What would be the size particles for this process? How can the efficiency of the process increased?
6) Define Froth Floatation. What is the criteria for froth floatation to take place? How does the machine dimensions affect the floatation process? Define flotation recovery. Explain the processes involved at the micro-level in flotation.
7) With a neat sketch describe the process of sintering in a Dwilght Lloyd machine. What are the restrictions for size of a particle during sintering process? What happens if the limiting fractions on minimum and maximum is bypassed?