1) Define the following terms: a) Calorie b) Flow Process

2) Choose the proper answer: (Positive, Negative)

a) Heat of reaction is ------, if the reaction is endothermic.

b) Heat of reaction is ------, if the reaction is exothermic.

3) What are the assumptions made in calculating values of standard heat of combustion?

4) Outline the Law of Conservation of Energy.

5) How to calculate the standard heat of reaction from heat of combustion and heat of formation?

6) Outline the material balance equations for crystallization operation with its block diagram.

7) Define i) Stoichiometry ii) Stoichiometric equation

8) What is limiting reactant and excess reactant?

9) Fill in the blank:

a) If we have to find out quantity of product formed from a reaction, we should go for ----------

b) If we have to find out quantity of unreacted reactant we should go for --------

10) Which of the following are balanced stoichiometric equations? Balance the reactions, if it is not balanced.

a) $2NaNO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + 2\ HNO_3$

b) $NaNO_3 + 0.5\ H_2SO_4 \longrightarrow 0.5Na_2SO_4 + HNO_3$

11) Define the following terms: a) Normality b) Weight fraction

12) Match the following

Name of compound	Valency
$KMnO_4$	3
H_3PO_4	5

13) Choose proper unit for the following from the bracket

{(ft.lbf)/s, cal/ (cm^2.s)}

a) Molar heat capacity b) Power

b)

14) Fill in the blank:

a) The sum of the mole fractions of all the components present in given system is equal to ----

b) Henry's law is valid when mole fraction is close to ----

15) Define partial pressure and give Dalton's law.

16) A mixture of CH_4 and C_2H_6 has an average molecular weight of 22.4. Find the mole% CH_4 and C_2H_6 in the mixture.

17) Explain Heat of formation and Heat of Combustion.

18) Explain Hess's law of Constant Heat Summation.

19) Describe various methods of expressing the composition of mixtures and solutions.

20) Explain the following terms: i) % Excess ii) % Conversion iii) Yield and iv) Selectivity.

21) Flue gases leaving the boiler stack at 250^0C have the following composition:
CO_2 = 11.31%, H_2O = 13.04%, O_2 = 2.17% and N_2 = 73.48% (by volume). Calculate the heat lost in 1 kmol of gas mixture above 25^0C, using the heat capacity data given below:
$C^0_p = a + bT + cT^2 + dT^3$

Gas	a	b X 10^3	cX10^6	dX10^9
CO_2	21.3655	64.2841	-41.0506	9.7999
H_2O	32.4921	0.0796	13.2107	-4.5474
O_2	26.0257	11.7551	-2.3426	-0.5623
N_2	29.5909	-5.141	13.1829	-4.968

22) i) Pure ethylene is heated from 30^0C to 250^0C at atmospheric pressure. Calculate the heat added per kmol ethylene using the heat capacity data given below:
$C^0_p = 4.1261 + 155.0213 \text{ X } 10^{-3} \text{ T} - 81.5455 \text{ X } 10^{-6} \text{ T}^2 + 16.9755 \text{ X } 10^{-9} \text{ T}^3$ **(4)**

ii) Calculate the heat of formation of liquid ethyl acetate at 298 K.
Data: Standard heat of formation of $CO_{2(g)}$ = -393.51 kJ/mol
Standard heat of formation of $H_2O_{(l)}$ = -285.83 kJ/mol
Standard heat of combustion of liquid ethyl acetate $C_4H_8O_2$ = -2230.91 kJ/mol **(4)**

23) A combustion chamber is fed with butane and excess air. Combustion of butane is complete. The composition of the combustion gases on volume basis is given as: CO_2 = 9.39%, H_2O=11.73%, O_2=4.70% and N_2=74.18%. Find the % excess air used and mole ratio of air to butane used.

24) An aqueous solution of pyridine containing 27% (by weight) pyridine and 73% (by weight) water is to be extracted with chlorobenzene. The feed and solvent are mixed well in a batch extractor and the mixture is then allowed to stand for phase separation. The extract phase contains 11% pyridine, 88.1% chlorobenzene and 0.9% water by weight. The raffinate phase contains 5% pyridine and 95% water by weight. Calculate: a) The quantities of two phases b) The weight ratio of solvent to feed based on 100 kg of feed.

25) In the manufacture of chlorine, feed containing hydrochloric acid gas and air are fed to an oxidiser. The product gases leaving the oxidiser are found to contain 13.2% HCl, 6.3% O_2, 42.9% N_2, 30% Cl_2 and 7.6% H_2O (by weight). Calculate (a) the percent excess air used (b) composition by weight of gases entering the oxidizer and (c) degree of completion of oxidation. Following reaction is taking place.

$$4\,HCl + O_2 \longrightarrow 2Cl_2 + 2H_2O$$

26) A single effect evaporator is fed with 15000 kg/h of weak liquor containing 13% caustic by weight and is concentrated to get thick liquor containing 37 % by weight caustic (NaOH). Calculate (a) kg/h of water evaporated and (b) kg/h of thick liquor obtained.

27) The waste acid from a nitrating process containing 20% HNO_3, 55% H_2SO_4 and 25% H_2O by weight is to be concentrated by addition of concentrated sulphuric acid containing 95% H_2SO_4 and concentrated nitric acid containing 90% HNO_3 to get desired mixed acid containing 26% HNO_3 and 60% H_2SO_4. Calculate the quantities of waste and concentrated acids required for 1000 kg of desired mixed acid.