BACHELOR OF CHEMICAL ENGINEERING EXAMINATION, THIRD YEAR
SECOND SEMESTER EXAM 2018 (Old)

**ENERGY RESOURCES & THEIR UTILIZATION**

Time: Three Hours Full Marks: 100

Answer any *four* questions
Assume missing data, if any
All the symbols/terms have usual significance

1. (i) Define the 'limits of inflammability' of a combustible gas. Elucidate the effect of temperature on 'explosive limits' with a suitable example.

1. (ii) The following data (Table 1) have been obtained from the TBP experiment of a crude oil (specific gravity=0.901 at 15.6 °C):

**Table 1**

| TBP range (°C) | $C_5$ - 93 | 93-175 | 175-286 | 286-325 | 325-365 | 365-542 | >542 |
|---|---|---|---|---|---|---|---|
| Yield(V/V)% | 3.50 | 11.49 | 26.00 | 18.00 | 13.25 | 22.00 | 5.14 |

Draw the TBP assay curve and determine TBP slope and 50% boiling point for the whole crude. Calculate the average boiling point and assess the base of the crude oil.

$$[K = \sqrt[3]{R} \quad /(0.827\rho)]$$

1. (iii) Explain graphically the significance of distillation of petroleum products boiling below 370 °C .

1.(iv) Briefly describe the principle of operation of a finned tube 'Waste heat boilers(WHB)' using a schematic. **[5+9+5+6]**

2.(i) Explain the principle of operation [mentioning the functions of all important parts] of a multi-blade type wind machine for driving a reciprocating pump. (Schematic not required)

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2.(ii)What is 'power density' ? How do you find the energy content of wind per unit area for a month?

2.(iii) Define 'cut in speed', 'design speed' and 'cut-out speed' for a wind machine . Draw a representative power density-duration curve and show the energy available for a wind machine.

2.(iv) Define 'power coefficient' and exhibit its typical variation with 'tip speed ratio' for 'multi blade' and 'propeller' type wind machine. **[5+5+ (3+5) + (2+5)]**

3. (i) What are the naturally occurring fissile and fertile nuclear fuels? What are the artificially produced fissile nuclei? Briefly elucidate 'Nuclear fission' considering U-235 as the fuel.

3. (ii) Illuminate the significance of 'neutron cross-section' and 'criticality of nuclear reaction'.

3. (iii) Briefly describe the functions of basic components (fuel, moderator, control rods, coolant, pressure vessel, steam generator and Containment) of a Pressurized Water Reactor (PWR) using a simplified schematic. **[(1+1+5) + (3+3) + (12)]**

4. (i) How are the 'washability curves' constructed from 'float and sink test' data for coal washing ? Explain using a representative table. What is the significance of washability curves ?

4. (ii) The following data were obtained in a boiler trial :

Analysis of coal: C: 80%; $H_2$: 5%; $O_2$ : 6%; S: 1%; $N_2$: 1%; $H_2O$: 2%; Ash: 5%

Analysis of flue gas: $CO_2$ : 11% ; CO: 1.5%; $O_2$ : 5.5%; $N_2$ : 82%

Temperature of flue gas: 275 °C ; Temperature of air : 20 °C

Calculate: (a)Total weight of flue gas/ kg coal; (b) Weight of excess air; (c) Heat in dry flue gas (sp. heat=1.025 kJ $kg^{-1}K^{-1}$ ); (d) Heat in excess air (sp. heat=0.996 kJ $kg^{-1}K^{-1}$ )

4. (iii) Using a simplified diagram, briefly describe the 'Low Temperature Carbonization' of coal . **[(6+2) + (2x4=8) + 9]**

5.(i) Briefly state the advantages of biodiesel over its petroleum equivalent ? What are the advantages of heterogeneous catalysts over their homogeneous counterparts in transeterification and esterification reactions for biodiesel production?

5. (ii) Write a short note on 'Fischer-Tropsch process' for production of liquid fuel.

5.(iii) Briefly discuss the production of 'biogas' from biomass through anaerobic digestion mentioning the pertinent reactions involved.

5.(iv) A coal has the following proximate analysis on air dried basis: M=1.5% , A=15.5% , VM=28%, FC = 55%. Calculate its ash% on dry basis and volatile matter on d.a.f and d.m.m.f basis. Repeat the calculation using the value of FC.

**[(4+2) +6 +6 + (3+4)]**

6.(i) Compute the overall loss coefficient for a flat plate collector with two glass covers with the following data:

Size of the absorber plate= 0.8 m x 1.5 m

Spacing between plate and first glass cover= 5 cm

Spacing between first and second glass cover= 5 cm

Emissivity of Absorber plate=0.90

Emissivity of glass cover=0.86

Collector tilt= 25°; Mean plate temperature= 80 °C; Atmospheric air temperature= 26 °C; Wind speed= 2.0 m/s; Back insulation thickness= 7 cm; Side insulation thickness= 3.5 cm; Thermal conductivity of insulation =0.04 W/m.K. Use the following correlation:

$$U_t = \left[\frac{M}{\left(\frac{C}{T_{pm}}\right)\left(\frac{T_{pm}-T_a}{M+f}\right)^{0.252}} + \frac{1}{h_w}\right]^{-1} + \left[\frac{\sigma(T_{pm}^2+T_a^2)(T_{pm}+T_a)}{\frac{1}{\varepsilon_p+0.0425M(1-\varepsilon_p)}+\frac{2M+f-1}{\varepsilon_c}-M}\right]$$

where $f = \left(\frac{9}{h_w}-\frac{30}{h_w^2}\right)\left(\frac{T_a}{316.9}\right)(1+0.091M)$

$C = 204.429(\cos\beta)^{0.252}/L^{0.24}$

$L$ = spacing (m)

6.(ii) Briefly explain the working principle of a 'solar pond' using a schematic.

6.(iii) Briefly elucidate the working principle of a 'solar cell'. What are 'fill factor' and 'maximum conversion efficiency' of a solar cell? **[12+6+ (3+4)]**