B. Tech.

(SEM. IV) EXAMINATION, 2006-07

INDUSTRIAL FUELS & PROCESS CALCULATIONS

Time : 3 Hours] [Total Marks : 100

Note : Attempt all question.

1 Attempt any four parts of the following: 5×4
   (a) Write the advantages and disadvantages of solid fuels.
   (b) Explain the sources of liquid fuels.
   (c) Write the limitations and availability of gaseous fuels.
   (d) Write the general uses of industrial fuels.
   (e) What do you understand by proximate and ultimate analysis of the coal.
   (f) Explain the phenomenon of coal beneficitation.

2 Attempt any four parts of the following: 5×4
   (a) Write the Seylers classification of the coal.
   (b) Explain gross and net calorific values of fuels.
   (c) Give the composition of coal tar.
   (d) Write the types of liquid fuels.
   (e) What is the difference between ‘commercial’ and non commercial energy sources.

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(f) In a double effect evaporator the second effect is maintained under vacuum of 475 mm Hg. Find the absolute pressure in kPa and Psi.

3 Attempt any two parts of the following:

(a) The equation for the heat transfer to or from a stream of gas flowing in turbulent motion is as follows:

\[ h = \alpha \frac{C_p G^{0.8}}{D^{0.2}} = 16.6 \frac{C_p G^{0.8}}{D^{0.2}} \]

where

- \( C_p \) = Heat capacity, as Btu/(lb)F°
- \( D \) = internal diameter of pipe as in
- \( G \) = mass velocity as \( \frac{lb}{(sec)(ft^2)} \)
- \( h \) = Heat transfer coefficient, as \( \frac{Btu}{hr ft^2 F°} \)

It is desired to transform the equation into new form

\[ h' = \alpha' C_p' \left(\frac{G'}{D'}\right)^{0.8} \]

\( C_p' \) = Heat capacity, as kcal/kg
\( D' \) = internal diameter of pipe as cm

\( G' \) = mass velocity, as \( \frac{(sec)(m^2)}{kg} \)

\( h' \) = Heat transfer coefficient, as \( \frac{k Cal}{hr \left(\frac{m^2}{C}\right)} \)
(b) Make the followings conversions:
(a) 294 g/l H₂SO₄ to normality.
(b) 4.8 mg/ml CaCl₂ to normality.
(c) 5N H₃PO₄ to g/l
(d) 54.75 g/l HCl to molarity
(e) 3M K₂SO₄ to g/l

(c) A producer gas made from coke has the following composition by volume:

<table>
<thead>
<tr>
<th>Component</th>
<th>Volume %</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>28.0%</td>
</tr>
<tr>
<td>CO₂</td>
<td>3.5%</td>
</tr>
<tr>
<td>O₂</td>
<td>0.5%</td>
</tr>
<tr>
<td>N₂</td>
<td>68.0%</td>
</tr>
</tbody>
</table>

This gas burned with such a quantity of air that the oxygen from the air is 20% in excess of net oxygen required for complete combustion. If combustion is 98% complete, calculate the weight and composition in volumetric percent of the gaseous products formed per 100 kg of gas burned.

4 Attempt any two parts of the following: 2x10

(a) The feed containing 60 Mole % A, 30 Mole % B and 10 Mole % inert enters a reactor. The product stream leaving the reactor is found to contain Z Mole % A. Reaction taking place is 2A + B → C. Find the percentage of original A getting converted to C.

(b) The ultimate analysis of a coal sample is given below:
Carbon = 61.5%, Hydrogen = 3.5%, Sulphur = 0.4%, Ash = 14.2%, Nitrogen = 1.8% and the rest oxygen
Calculate:
(i) Theoretical oxygen required per unit weight of coal.
(ii) Theoretical dry air requirement per unit weight of fuel.
(iii) The Orsat analysis of flue gases when the coal is burned with 90% excess dry air.
(c) A gas (B) – benzene (A) Mixture is saturated at 1 std atm, 50°C. Calculate the absolute humidity if B is (a) nitrogen and (b) carbon dioxide. The partial pressure of benzene is 0.362 std atm.

5 Attempt any two parts of the following: 10×2
(a) From the following bond energies and standard ΔH° values for the formation of elements in gaseous state, calculate the standard heat of formation of acetone.

<table>
<thead>
<tr>
<th>Bond Energies</th>
<th>Standard ΔH°</th>
</tr>
</thead>
<tbody>
<tr>
<td>H (g) = 52.1 kcal</td>
<td>C-H = 99 kcal</td>
</tr>
<tr>
<td>O (g) = 59.16 kcal</td>
<td>C-C = 80 kcal</td>
</tr>
<tr>
<td>C (g) = 171.7 kcal</td>
<td>C = O = 81 kcal</td>
</tr>
</tbody>
</table>

(b) Calculate the heat that must be removed in cooling 32 kg of oxygen from 488 K (215°C) to 313 K (40°C) using \( C_p^O \) data:

\[ C_p^O = a + bT + cT^2 + dT^3, \text{ kJ/kmolK} \]

<table>
<thead>
<tr>
<th>Gas</th>
<th>a</th>
<th>b×10^3</th>
<th>c×10^6</th>
<th>d×10^9</th>
</tr>
</thead>
<tbody>
<tr>
<td>O_2</td>
<td>26.0257</td>
<td>11.7551</td>
<td>-2.3426</td>
<td>-0.5623</td>
</tr>
</tbody>
</table>

(c) Write the short notes on the following:
(a) Heat of combustion
(b) Heat of formation
(c) Heat capacity and latent heat
(d) Relationship between \( C_p \) and \( q \) for ideal gas
(e) Hess’s law of constant heat summation.