Question (1): Manufacturing of cement required the availability of raw materials containing the necessary oxides for the formation cement compounds. List these oxides and their relative percentages.

<table>
<thead>
<tr>
<th>Oxide</th>
<th>Name</th>
<th>Abbreviation</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CaO</td>
<td>Calcium oxide</td>
<td>C</td>
<td>(60 - 67)%</td>
</tr>
<tr>
<td>SiO₂</td>
<td>Silicon oxide</td>
<td>S</td>
<td>(16 - 25)%</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>Aluminum oxide</td>
<td>A</td>
<td>(3 - 8)%</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>Ferric oxide</td>
<td>F</td>
<td>(0.3 - 6)%</td>
</tr>
<tr>
<td>(Na₂O-K₂O)</td>
<td>Alkalies</td>
<td>N,K</td>
<td></td>
</tr>
<tr>
<td>TiO₂</td>
<td>Titania oxide</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td>MgO</td>
<td>Magnesia oxide</td>
<td>M</td>
<td></td>
</tr>
<tr>
<td>PbO₅</td>
<td>Phosphoric oxide</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td>SO₃</td>
<td>Sulfate oxide</td>
<td>S</td>
<td></td>
</tr>
</tbody>
</table>

Question (2): Draw schematic diagram for typical Kiln and show the different reactions at the different temperature zones.
Question (3): Lime content (CaO) in the raw materials must be within certain limits. Explain the problems associated with high or low content.

High (CaO) content:

- Problems associated with high content of CaO, i.e., CaO > (CaO) max.
- Excessive amount of uncombined lime causing increase in volume of cement and cracking.
- Burnability problems because the CaO needs a high degree of temperature to be set in reaction with other oxides.

Low (CaO) content:

- Slow rate of development of strength in cement.
- Dusting of the kiln because of the conversion of βC2S to γC2S.

Question (4): Hydration of portland cement goes through different stages, explain.

Stage I: Pre-dormant period.

- It takes from 6-15 minutes after adding water to the cement.
- Instantaneous formation of primary ettringite due to hydration of C4A.
- Liberation of (C-S-H) and Ca(OH)2 due to hydration of C3S.
- The primary ettringite and the (C-S-H) cover the C3S and C4A phases of cement slow down their rate of hydration.
- A huge amount of heat is liberated in this stage.

Stage II: Dormant period.

- It takes about (1-2) hr from the termination of the pre-dormant period.
- The hydration of C3S and C4A slows down.
- The (C-S-H) and primary ettringite covering C3S and C4A break down at the end of this period and the hydration of C3A and C2S continues.
Stage III - Acceleration period:

- It takes (4-6) hr from the termination of the dormant period.
- The hydration of C3S continues vigorously.
- The amount of water reduced because of chemical reactions and adsorption.
- The initial setting time takes place and the beginning of this period.
- The porosity and impermeability increased in this period due to the formation of (C-S-H) and (CH).
- The final setting time begins at the end of this period.

Stage IV: Declaration and steady period:

- The hydration of C3S continues and the hydration of C3S starts in this period and due to the diffusion water rather than chemical reactions.
- The hydration of C3S resumes.
- The formation of primary ettringite comes to an end after 18 to 24 hrs.
- The impermeability continues to increase.
Question (5): Portlandite (Ca(OH)\textsubscript{2}), produced during hydration has both beneficial and damaging attributes, explain.

- Carbonation
- Leachable Water
- Expansive Ettringite
- Sulfate combined with Ca(OH)\textsubscript{2}
- Delignifying attributes
- Beneficial effect
- Reservoirs Reactivity (PR)

Ca(OH)\textsubscript{2} in about 20\% of heat,
it could be controlled by C5/S5 ratio,
the damaging attributes could be less when adding Pozzolanic Materials.

Question (6): Explain the features of the pozzolanic reactions.

There are three features of the pozzolanic reactions:

1. The pozzolanic reaction is slow, that's why the rate of strength in the first period is very low and the concrete need a long period of curing.

2. The reaction is time consuming rather than producing.

3. The replacing of Ca(OH)\textsubscript{2} by secondary C-S-H enhanced the physical properties of the cement paste in two ways:
   (a) pore size refinement
   (b) grain size refinement

both of them improve the strength and the durability of the concrete.
Question (7): Explain the effect of addition of mineral admixtures on early gain of strength, shrinkage and bleeding.

* Bleeding - due to fineness of mineral admixtures it works as filler to the capillary voids and increases the tortuosity of the flow channel so it decreases the bleeding.
* Drying shrinkage: due the decreasing in bleeding when adding mineral admixture the surface of the concrete dry quickly making tensile stress on concrete surface and causing increase in cracking due to shrinkage.
* Early gain strength: due the dilution of active materials (C-S-H and C-A-S-H) with less active mineral admixture the rate of hydration and the early strength are very slow. So the mineral admixture decrease the early gain of strength.

Question (8): Addition of microsilica improve significantly the compression strength, explain.

The microsilica improve significantly the compression strength due to:

1) Fineness of the grain, and it role as a filler and increase the density of the mix.
2) the production of secondary (C-S-H) and the replacing of CSH/H2O decrease the thin layer of transition zone which is the weakest part of the concrete.

The improving of the compression strength influenced by many factors:

1) microsilica content
2) water/c content
3) rate of hydration
4) curing period
5) temperature
6) The fineness of P.C particles and SF particles
Question (9): The reaction of Fly Ash with portland cement depends on many factors, explain these factors.

There are many factors that Fly Ash reactivity depends on:

1. Morphology of the Fly Ash
2. Fineness of the particles of Fly Ash and PC
3. The chemical compound of Fly Ash and PC
4. The Alkali-hydrate concentration in paste of Fly Ash and PC
5. The development of heat generating in the stages of reaction between FA and PC
6. The amount of water reduced in the event of FA and PC

Question (10): Explain the reaction of C₃A compound with sulfate during early hydration time in case there is more of C₃A (or less) compare to the sulfate quantity.

<table>
<thead>
<tr>
<th>C₃A</th>
<th>Sulfate</th>
<th>Setting time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Low</td>
<td>I</td>
</tr>
<tr>
<td>High</td>
<td>High</td>
<td>II</td>
</tr>
<tr>
<td>High</td>
<td>Low</td>
<td>III</td>
</tr>
<tr>
<td>High</td>
<td>Very low or nil</td>
<td>IV</td>
</tr>
<tr>
<td>Low</td>
<td>High</td>
<td>V</td>
</tr>
</tbody>
</table>

Who are these cases?