A. Review of Definitions and Terminology:

1. Ceramic = Any compound involving metallic and non-metallic elements (e.g., MX)
   a. Enamel = ceramic coating over a substrate
   b. Porcelain = ceramic based on K-Al-Silicate (K₂O-Al₂O₃-SiO₂)
      (1) Dental Porcelain = narrow range of porcelains

B. Review of Ceramic Structure:

1. Arrangement: mixture of crystalline and non-crystalline phases
2. Bonding: ionic and/or covalent
3. Composition:
   a. Silicate Types Used to Produce Porcelain:
      (1) Clays (hydrated aluminosilicates)
      (2) Feldspars (anhydrous aluminosilicates)
      (3) Quartz (silica)
   b. Non-Silicate Types (e.g., MgO)

4. Defects: pores and cracks

C. Review of Ceramic Properties:

1. Physical Properties:
   a. Intermediate density (1.0-3.8 gms/cc)
   b. High melting point (= refractory)
   c. Low coefficient of thermal expansion (1-15 ppm/°C)

2. Chemical Properties:
   a. Low chemical reactivity
   b. Low absorption and solubility

3. Mechanical Properties:
   a. High modulus
   b. Much stronger in compression than tension (~10X)
   c. Brittle (low plastic deformation (<0.1%); low fracture toughness

4. Biological Properties:
   a. Relatively inert

D. Classification Systems for Dental Porcelains:

A. Classification Systems for Dental Porcelains:

1. Classification based on fusion (vitrification) temperature:
   a. High-fusing: 1288 to 1371 °C (2350 to 2500 °F)
   b. Medium fusing: 1093 to 1260 °C (2000 to 2300 °F)
   c. Low fusing: 871 to 1066 °C (1600 to 1950 °F)

2. Classification by restoration component:
   a. Porcelain core
   b. Porcelain inlay
   c. Cast porcelain
   d. PFM

3. Classification based on esthetic role of porcelain:
   a. Opaque porcelain
   b. Body porcelain (incisal or enamel; gingival or dentin; modifier)
   c. Stains or glazes

B. Chemical Analyses of Low Fusing Porcelains:

<table>
<thead>
<tr>
<th>Composition</th>
<th>Weight Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al₂O₃</td>
<td>10.80</td>
</tr>
<tr>
<td>SiO₂</td>
<td>52.16</td>
</tr>
<tr>
<td>K₂O</td>
<td>27.14</td>
</tr>
<tr>
<td>Na₂O</td>
<td>5.95</td>
</tr>
<tr>
<td>CaO</td>
<td>6.66</td>
</tr>
<tr>
<td>MgO</td>
<td>0.53</td>
</tr>
<tr>
<td>ZnO</td>
<td>0.13</td>
</tr>
<tr>
<td>TiO₂</td>
<td>0.61</td>
</tr>
<tr>
<td>B₂O₃</td>
<td>0.27</td>
</tr>
<tr>
<td>SnO₂</td>
<td>0.32</td>
</tr>
<tr>
<td>ZrO₂</td>
<td>0.30</td>
</tr>
<tr>
<td>CO₂</td>
<td>0.10</td>
</tr>
<tr>
<td>H₂O</td>
<td>0.02</td>
</tr>
</tbody>
</table>

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**DENTAL PORCELAIN**  
Fabrication Techniques (Vitrification)

A. Definitions and Terminology Related to Manipulation:
1. Condensation = padding or packing of wet porcelain into position
2. Biscuit = cohesive power compact
3. Frit = unfused or partially fused compact
4. Firing = fused high-melting point compacting and eliminating porosity
5. Soaking = holding at high temperature

PT T. Tricks for Firing:
- Minimize number of firings.
- Use lower temperatures and longer times.
- Always heat very slowly.
- Use vacuum furnace.
- Use fine-grained powders for finer porosity.

**Porcelain Application**

<table>
<thead>
<tr>
<th>Application</th>
<th>Vacuum Furnace</th>
<th>Porcelain</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

**Strengthening Mechanisms for Dental Porcelain**

A. Alumina Reinforcement:
1. Alumina or leucite crystalline phases act as reinforcement
2. Cracks stopped by crystalline phases

B. Porcelain-Fused-to-Metal Bonding:
- Prevents porcelain fracture
1. Use high-modulus thick metal substructures for stiffness
2. Porcelain bonded to metal

C. Porcelain-Fused-to-Metal Bonding:
- Porcelain Pre-stressing
1. Make metal CTE slightly greater than porcelain
2. On cooling, the metal places porcelain in compression

**FLEXURAL STRENGTH**
Dependence on Surface Defects

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>Fine</th>
<th>Medium</th>
<th>Coarse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pristine</td>
<td>320 ± 50</td>
<td>223 ± 21</td>
<td>126 ± 14</td>
</tr>
<tr>
<td>Sandblasted</td>
<td>120 ± 13</td>
<td>191 ± 9</td>
<td>98 ± 13</td>
</tr>
<tr>
<td>Ground</td>
<td>96 ± 16</td>
<td>183 ± 16</td>
<td>136 ± 10</td>
</tr>
<tr>
<td>Machined</td>
<td>42 ± 6</td>
<td>61 ± 16</td>
<td>90 ± 4</td>
</tr>
<tr>
<td>Fatigued</td>
<td>122 ± 10</td>
<td>187 ± 11</td>
<td>108 ± 6</td>
</tr>
</tbody>
</table>

THANK YOU