INTRODUCTION:

A. Overview of Dental Cements:

1. Definitions:
   a. Luting = retention to small undercuts on tooth/restoration surfaces from cutting
   b. Bonding = retention to microscopic undercuts due to etching, hybridization, etc.

2. Principal Goals:
   a. Retention
   b. Sealing (Elimination of microleakage)

3. Theories of Pulpal Irritation:
   a. Fluid Flow (Sensitivity)
   b. Bacterial Endotoxins (Inflammation)

B. Evolution of Dental Cements:

C. Classification by Components:

1. Zinc Oxide Eugenol
   a. Unmodified (ZOE) Eugenol ZnO
   b. Reinforced (ZOE-Reinf) Eugenol ZnO, Polymer, Rosin
   c. ZOE-EBA (EBA) Eugenol / EBA ZnO, Al2O3, Rosin
   d. HV-EBA (Exp) HV/EBA ZnO, Al2O3, Rosin

2. Zinc Phosphate (ZP)
   a. Unmodified (SC) H3PO4 / H2O Silicate
   b. Zinc Silico-phosphate (SPC) H3PO4 / H2O ZnO,Silicate

3. Silicate
   a. Unmodified (SC) H3PO4 / H2O Silicate
   b. Zinc Silico-phosphate (SPC) H3PO4 / H2O ZnO,Silicate

4. Polycarboxylate (PCC) PAA / H2O ZnO

5. Glass Ionomer
   a. Conventional (GI) PAA / H2O Silicate
   b. Resin Modified (RH-GI) PAA, Resin, HEMA Silicate, Resins
   c. Compomer (CC) (Monomers) (F-Al-Silicate Fillers)

6. Composite or Resin (+DBS) (CP or RC) (Monomers) (Silicate Fillers)

D. Composite Analysis of Dental Cements Formulations:

1. Before the reaction:
   a. Continuous Phase:
      (1) Acid functional LIQUID
      (2) Catalyst
   b. Dispersed Phase:
      (1) Base functional POWDER
      (2) (Reinforcing Polymer)

2. After the reaction:
   a. Continuous Phase
      (1) Reaction Product MATRIX
      (2) Residual Catalyst
   b. Dispersed Phase
      (1) Residual POWDER
      (2) (Reinforcing Polymer)
E. Dental Cement Reactions:

1. Overall Reaction Conversion for Powder: (approximately 12 v/o)
2. Overall Reaction Conversion for Liquid:

3. Monitoring of Initial Reaction:

4. Control of Reaction Variables and Final Properties:
   (* All controlled by the operator.)
   a. MIXING Interval Variables:
      (1) Temperature
      (2) % Relative Humidity
      (3) P/L Ratio
      (4) Mixing Procedures
   b. WORKING Interval Variables:
      (1) Time of Placement
   c. SETTING Interval Variables:
      (1) Thickness
      (2) Disturbances
DENTAL CEMENT PROPERTIES:

A. Overview of Dental Cement Properties:

1. Physical Properties:
   a. Coefficient of Thermal Expansion
   b. Thermal Conductivity (= insulators)
2. Chemical Properties:
   a. Solubility and Disintegration
   b. Absorption
3. Mechanical Properties:
   a. Compressive Strength
   b. Tensile Strength
   c. Shear Strength
   d. Bond Strength
4. Biological Properties:
   a. Chemical irritation of pulp by components prior to setting
   b. Chemical diffusion of unreacted components to pulp

B. ADA Solubility Test:

1. Specification #8: Zinc Phosphate Cement (cement wafer used; 1 hr old; 37 °C; H₂O immersion; pH=7; measure weight loss indirectly after 1 day or 7 days)

2. Problems with lab solubility test -- lab data conflict with clinical data.

C. Short-Term Clinical Performance of Luting Cements (3 Year Retention Rate):


1. Zinc Phosphate           Crowns = 100%    Bridges = 98%
2. Polycarboxylate          96%             95%
3. Reinforced ZOE, ZOE-EBA  98%             92%
D. Long-Term Clinical Performance of Luting Cements (Dissolution):

Multifactorial Solubility and Disintegration Events:

- ZnO
- MgO
- Tertiary ZP Crystals
- Zn(OH)$_2$
- Mg(OH)$_2$
- Zn(PO$_4$)$_2$
- H$_2$O, Lactic acid
- Na$^+$, Cl$^-$
- F$^-$
- Ca$^+$, K$^+$

Ryskewitsch. *J Am Ceram Soc* 1953;36:65. (Empirical suggestion $\sigma = \sigma_0 \exp(-nP)$ where $n=4$-$7$ and $P$=volume fraction porosity.)
DENTAL CEMENT STRUCTURE AND MANIPULATION:

A1. Zinc Oxide/ Eugenol Cement: and
A2. Zinc Oxide/ Eugenol Cement: (Reinforced ZOE)

1. Chemistry:
   a. Continuous Phase:
      Acid functional liquid    = Eugenol
      Catalysts                  = H₂O, Acetic Acid, Zinc Acetate, CaCl₂
   b. Dispersed Phase:
      Base functional powder    = Zinc Oxide
      Fillers or modifiers      = MgO, PMMA, Silica,…

2. Setting Reaction:
   a. Slow Reaction; Stepwise Reaction; Very little exotherm
   b. Crystalline Reaction Product = Zinc Eugenolate Chelate
   c. H₂O required to make reaction occur.

3. Manipulation and Technique Considerations:
   a. P/L should be mixed thoroughly:
      -- Method of powder addition is not very critical.
      -- Method of spatulation is not very critical.
   b. Reaction not very temperature sensitive because reaction is slow.
   c. H₂O in air and on oral surfaces accelerates the reaction.
A3. ZOE-EBA Cements:

1. Chemistry:
   a. Continuous Phase:
      Acid functional liquid = Eugenol (33%), EBA (67%)
      Catalysts = None required
   b. Dispersed Phase:
      Base functional powder = Zinc Oxide
      Fillers or modifiers = MgO, Al₂O₃

2. Setting Reaction:
   a. Slow Reaction; Stepwise Reaction; More exothermic than ZOE.
   b. Crystalline Reaction Product = ZE + ZEBA.
      (Zinc ethoxybenzoate crystallizes slowly from amorphous matrix).
   c. H₂O produced as by-product of reaction.

3. Manipulation and Technique Considerations:
   a. Reaction not very temperature sensitive because reaction is slow.
   b. P/L should be mixed thoroughly:
      -- Method of powder addition is not very critical.
      -- Method of spatulation is not very critical.
      -- Mixing is relatively difficult.
B. Zinc Phosphate Cement:

1. Chemistry:
   a. Continuous Phase:
      Acid functional liquid = 28-38 w/o H₃PO₄ in H₂O
      Catalysts = None required (strong acid)
      Retarders = Aluminum phosphate and zinc phosphate buffers.
   b. Dispersed Phase:
      Base functional powder = 90ZnO-10MgO (Heat treated)
      Modifiers = (Silica)

\[
\begin{align*}
\text{ZnO} + 2 \text{H}_3\text{PO}_4 + \text{H}_2\text{O} & \rightarrow \text{Zn(H}_2\text{PO}_4)_2\cdot\text{H}_2\text{O} \text{ on mixing} \\
\text{Zn(H}_2\text{PO}_4)_2\cdot\text{H}_2\text{O} + 2\text{ZnO} & \rightarrow \text{Zn}_3(\text{PO}_4)_2\cdot4\text{H}_2\text{O} \text{ on mixing (tertiary zinc phosphate)}
\end{align*}
\]

Fleck's ZP Powder 1000 X  
Tert. ZP Crystals 40,000 X

2. Setting Reaction:
   a. Extremely exothermic reaction:
      *Buffers in liquid slow reaction.
      *Heat treatment of P slows reaction.
   b. Crystalline Rx products = tertiary zinc phosphate.

3. Manipulation and Technique Considerations:
   a. Reaction is sensitive to:
      Temperature.
      *H₂O in liquid (CONTROLS IONIZATION).
   b. P/L manipulation controls reaction and properties:
      *Mix on CHILLED glass slab.
      *Dispense P and L at a RATIO of 2.0 or higher.
      *Incorporate powder INCREMENTALLY over 90-120 secs.
      *SPATULATE thoroughly to dissipate heat of reaction.
C1. Silicate Cements:

1. Chemistry:
   a. Continuous Phase:
      Acid functional liquid = 42 w/o H₃PO₄ in H₂O
      Catalyst = None required (strong acid)
      Retarder = 18 w/o Al or Zn phosphate
   b. Dispersed Phase:
      Base functional powder = Alloy of SiO₂ / Al₂O₃ / Na₃AlF₆ / Ca(H₂PO₄)₂.H₂O
      Modifiers = None

   Powder components fused to glass at 1400 C
   Fluorides and Al phosphates act as ceramic fluxes
   Hot glass is fritted by quenching and then ground
   Powder reactivity depends on Al/Si ratio

2. Setting Reaction:
   a. Extremely exothermic reaction:
   b. Reaction product matrix = amorphous alunino-phosphate gel.
   c. Stages of reaction:
      Mixing: initial contact of liquid with base powder
      Working: ion migration during powder dissolution
      Setting: metal/phosphate precipitation
      (Reaction continues for hours to days)

3. Manipulation and Technique Considerations:
   a. Reaction is sensitive to:
      Temperature.
      H₂O content of liquid (CONTROLS IONIZATION).
      Spatulate over small area to minimize water loss.
   b. P/L manipulation controls reaction and final properties:
      Mix on CHILLED glass slab.
      Dispense P and L at a RATIO of 2.0 or higher.
      Incorporate powder in 3 increments over 90-120 secs.

C2. Zinc Silico-phosphate Cements:

1. Chemistry: Mixture of zinc phosphate and silicate components
2. Setting Mechanisms: combination of zinc phosphate and silicate cements
3. Manipulation and Techniques: see Silicate Cements
D. Polycarboxylate Cements:

1. Chemistry:
   a. Continuous Phase:  
      Acid functional liquid  = 50 w/o acid polymer based on  
      acrylic, itaconic, maleic, tartaric  
      in H₂O  
   b. Dispersed Phase:  
      Base functional powder  = ZnO  
      Modifiers  = None  

   Amorphous matrix of  
   crosslinked PAA chains.  

   Pores remaining after  
   erosion removed ZnO.  

   Durelon Cement (after erosion of residual ZnO from matrix)  
   1000 X  

2. Setting Reaction:
   a. Exothermic reaction; Relatively fast; Cannot be retarded!  
   b. Amorphous crosslinked polymer formed during setting:  
      Chains bonded to each other by Zn ion chelation.  
      Chains bonded to Zn ions on residual ZnO powder.  
      Chains bonded to Ca ions on tooth structure surface.  

3. Manipulation and Technique Considerations:
   a. Reaction is sensitive to:  
      Temperature.  
      H₂O content of liquid (CONTROLS IONIZATION).  
   b. P/L mixed carefully to control reaction and properties:  
      Mix CHILLED COMPONENTS on paper pad.  
      Dispense P and L at ratio of 1.5 to 2.0  
      Incorporate P QUICKLY over 15-30 secs all at once.  
      Spatulate thoroughly but not after 30 secs mix time.  
   c. Product variations: Regular set (C+B); Fast set (ortho, pedo)  
   d. Setting times = 3-5 mins at 37 C
E1. Glass Ionomer Cements:

1. Chemistry:
   a. Continuous Phase:
      Acid functional liquid = 50 w/o acid functional polymer (AA, Itaconic, Tartaric, Maleic)
      H₂O
   b. Dispersed Phase:
      Base functional powder = Alloy of SiO₂/ Al₂O₃/ Na₃AlF₆/ Ca(H₂PO₄)₂·H₂O
      Modifiers = None

![Diagram of Glass Ionomer Cements](image)

2. Setting Reaction:
   b. Reaction product matrix = amorphous Al-polyacrylate gel.
   c. Stages of reaction:
      Mixing: initial contact of liquid with base powder
      Working: ion migration during powder dissolution
      Setting: Ca-acrylate gel replaced by Al-acrylate gel (reaction continues for 24-72 hrs); silicate matrix produced as well over 30 days.

![Diagram of Setting Reaction](image)

3. Manipulation and Technique Considerations:
   a. Reaction is sensitive to: Temperature.
   b. P/L manipulation controls reaction and final properties:
E2. Resin Modified Glass Ionomer Cements:

1. Chemistry:
   a. Continuous Phase:
   b. Dispersed Phase:
2. Setting Reaction:
3. Manipulation and Technique Considerations:
F. Composite Cements: (composite + bonding to tooth + bonding to ceramic)

1. Chemistry of composite (resin) cements:
   a. Continuous Phase: = ~40 w/o difunctional monomers
   b. Dispersed Phase: = ~60 w/o silicate glass filler

2. Setting Reaction: SC or DC chain reaction polymerization

3. Manipulation and Technique Considerations:
   a. Difficult to VLC the cement under a restoration
   b. Shrinkage may produce stresses on bonding system

4. Commercial Examples:
   a. Metallic Restorations (Bonding, Luting Composite)
   b. Ceramic Restorations (Bonding, Luting Composite, Coupling):
   c. Composite Inlays (Bonding, Luting Composite, Coupling):

<table>
<thead>
<tr>
<th>Commercial</th>
<th>System:</th>
<th>Manufacturer:</th>
<th>Luting System:</th>
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<tbody>
<tr>
<td>C&amp;B Metabond</td>
<td>Parkell</td>
<td>None</td>
<td>(4-META)</td>
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<tr>
<td>CR Inlay Cement</td>
<td>J. Morita</td>
<td>Clearfil Photo-Bond</td>
<td>(Phosphate)</td>
</tr>
<tr>
<td>Panavia</td>
<td>J. Morita</td>
<td>None</td>
<td>(Phosphonate)</td>
</tr>
<tr>
<td>Panavia 21</td>
<td>J. Morita</td>
<td>ED Primer</td>
<td>(Phosphonate)</td>
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<tr>
<td>Resinomer</td>
<td>Bisco</td>
<td>All-Bond 2</td>
<td>(MTG-GMA)</td>
</tr>
<tr>
<td>Pent-Core Plus (Cement Kit)</td>
<td>Jeneric/Pentron</td>
<td>Pent-Core Plus</td>
<td>(PCDMA, HEMA)</td>
</tr>
</tbody>
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COMMERCIAL EXAMPLES OF DENTAL CEMENTS:

A. Zinc Oxide Eugenol Cements (ZOE):
   - ZOE 2200 (LD Caulk)
   - ZOE (J. Bird Moyer Co.)
   - ZOE Temporary (LD Caulk)
   - ZOGENOL (Stratford Cookson)

Reinforced ZOE Cements (RZOE):
   - ZOE B+T (LD Caulk)
   - IRM (LD Caulk)
   - FYNAL (LD Caulk)
   - ZEBACEM (LD Caulk)
   - OPOTOW ALUMINA-EBA (Getz)
   - AURACEM (DMG Hamburg)

Hexyl Vanillate Cements (HV, Experimental):
   - None currently marketed

B. Zinc Phosphate Cements (ZP):
   - MODERN TENACIN (LD Caulk)
   - FLECK'S EXTRAORDINARY (Mizzy)
   - SMITH'S ZINC CEMENT (Teledyne)
   - AMES Z-M (Teledyne)
   - KENT ZINC CEMENT (Stratford Cookson)
   - LANG-C+B Only (Lang)
   - S-C (Stratford Cookson)
   - DROPSIN (Atwood Industries)
   - ELITE (I.D.T. Corp)

C1. Silicate Cements (SC):
   - AMES PLASTIC Porcelain (Teledyne)
   - ASTRALIT (Premier)
   - SYNTREX F (Premier)
   - SILICAP (HD Justi)

Zinc Silico-phosphate Cements (ZSP):

D. Polycarboxylate Cements (PC):
   - TYLOK (LD Caulk)
   - DURELON (Premier)
   - CHEMIX (Harry J. Bosworth)
   - CARBOXYLON (3M)
   - POLY-F (DeTrey)

E1. Glass Ionomer (GI):
   - ASPA (LD Caulk)
   - IONOMER (Denmat)
   - FUJI II (GC America)
   - KETAC-CEM (ESPE-Premier)
   - VITREBOND CEMENT (3M)
   - BIOBOND LUTING (Harry J. Bosworth)

E2. Resin-Modified Glass Ionomer (RMGI):
   - FUJI I (GC)
   - RELY-X LUTING (VITREMER CEMENT) (3M)
   - ADVANCE (LD Caulk)
   - PRINCIPLE (LD Caulk)
   - NEXUS (Kerr)
   - DYRACT CEM (Dentsply)
   - PERMACEM (DMG Hamburg)

F. (Resin) Composite Cements (CC):
   - COMSPAN (LD Caulk)
   - PANAVIA F (Kuraray)
   - PANAVIA 21 (Kuraray)
   - ENFORCCE (LD Caulk)
   - RESIN CEMENT (3M)
   - NEXUS (Kerr)
   - MEGABOND (Harry J. Bosworth)
   - DUO-CEMENT (Coltene)
   - CALIBRA (LD Caulk)
   - OPAL LUTING (3M)

G. Compomer Cements:
   - UNICEM (3M-ESPE)
   - MAXCEM (Kerr)
   - MultiLink (Heraeus-Kulzer)
MULTIPLE CHOICE STUDY QUESTIONS:

1. What are the two major goals for luting cements?
   a. Retention and sealing
   b. Hybrid layer formation and pulpal medication
   c. Stress distribution and chemical bonding to the restoration
   d. Minimal chemical irritation of the pulp and high strength
   e. Thermal insulation and chemical bonding to tooth structure

2. Which one of the following situations causes pulpal inflammation?
   a. Fluid movement in dental tubules
   b. High acidity of dental cements
   c. Long-term decomposition of cement reactions products
   d. Diffusion of endotoxins to the pulp
   e. High concentrations of sucrose in saliva near open tubules

3. Which ONE of the following is the most important property for dental cement to guarantee long term clinical success?
   a. Compressive strength
   b. Resistance to solubility and disintegration
   c. Low coefficient of thermal expansion
   d. Radiopacity similar to tooth structure
   e. Setting contraction

4. Microleakage of bacterial endotoxins will result in:
   a. Pulpal inflammation
   b. Sensitivity
   c. Cement dissolution
   d. Loss of adhesion to dentin
   e. Plaque formation under the cement

5. Which one of the following is the reason that dental cements cannot be easily reacted by light-curing methods alone?
   a. Inadequate access
   b. Oxygen inhibition of thin films
   c. Excessive polymerization shrinkage
   d. Visible light heating effects on the pulp
   e. Dentin absorption in the visible light range

6. The overall reaction and properties of dental cements are most appropriately analyzed in terms of:
   a. Non-crystalline ceramics
   b. Non-crystalline polymers
   c. Rule-of-mixtures for composites
   d. Griffith-Orowan theory
   e. Brannstrom theory

7. Which ONE of the following dental cements does NOT contain zinc oxide as part of its powder composition?
   a. Zinc phosphate cement
   b. Zinc silico-phosphate cement
   c. ZOE cement
   d. Durelon cement
   e. Silicate cement
8. Which ONE of the following dental cements does NOT contain water as part of the composition of the liquid component?
   a. ZP
   b. ZOE
   c. PCC
   d. SC
   e. GI

9. Which one of the following has an extremely important effect on the final properties of a dental cement?
   a. P/L ratio
   b. Temperature at mixing
   c. Relative humidity
   d. Rate of mixing
   e. Amount of ambient light

10. What is the effect of 10% porosity on the strength of dental cement?
    a. 10% increase
    b. 10% decrease
    c. 20% decrease
    d. 50% decrease
    e. None

11. Phosphoric acid SOLUTIONS which are used as the liquid component of zinc phosphate and silico-phosphate cements have an INITIAL pH value of:
    a. 0.1 to 1.0
    b. 1.0 to 2.0
    c. 2.0 to 3.0
    d. 3.0 to 5.0
    e. 5.0 to 7.0

12. Which ONE of the following cements uses a liquid that is an aqueous solution of polymer?
    a. ZP
    b. ZOE-EBA
    c. GI
    d. SPC
    e. SC

13. During the initial setting reaction for dental cements, approximately what percentage of powder is reacted?
    a. 10 to 25%
    b. 25 to 50%
    c. 50 to 75%
    d. 75 to 90%
    e. 90 to 100%

14. Approximately what LEVEL of cement setting reaction is complete after the first hour?
    a. 0-25%
    b. 25-50%
    c. 50-75%
    d. 75-90%
    e. 90-100%
15. **What is the method of determining the SETTING TIME for dental cement reactions?**
   a. Peak exotherm of the reaction
   b. Time interval to 150 psi strength
   c. Large Gilmore needle
   d. Loss of gloss
   e. None of the above

16. **Which ONE of the following cements should be mixed on a chilled glass slab?**
   a. ZOE cement
   b. ZOE reinforced cement
   c. ZOE-EBA cement
   d. Zinc phosphate cement
   e. Polycarboxylate cement

17. **For which ONE of the following dental cement types is the incremental addition of powder to the liquid extremely important during the mixing of the cement?**
   a. CP
   b. PCC
   c. ZP
   d. ZOE
   e. GI

18. **Which ONE of the following ZINC PHOSPHATE cement COMPONENTS primarily CONTROLS the reactivity of the powder and the liquid during mixing?**
   a. Zinc oxide powder particle size
   b. Magnesium oxide additives
   c. Aluminum phosphate buffers
   d. Zinc phosphate buffers
   e. Water content of the liquid

19. **Which ONE of the following mixing methods is correct for zinc phosphate cement manipulation?**
   a. 6 incremental additions of P over 90-120 sec with stropping on chilled glass slab.
   b. 3 incremental additions of P over 90-120 sec using a chilled glass slab.
   c. Rapid combination of all P into all L at the outset.
   d. 3 incremental additions over 120 sec using a paper mixing pad.
   e. None of the above.

20. **Which ONE of the following dental cement phases is NOT CRYSTALLINE?**
   a. Zinc eugenolate
   b. Tertiary zinc phosphate
   c. Zinc oxide
   d. Magnesium oxide
   e. Zinc polyacrylate

21. **The setting reaction of Fleck’s Mizzy dental cement creates which ONE of the following reaction products in the matrix?**
   a. Zinc ethoxybenzoate
   b. Zinc eugenolate
   c. Tertiary zinc phosphate
   d. Zinc polyacrylate gel
   e. Calcium phosphate
22. Which ONE of the following methods is acceptable for retarding the polycarboxylate cement reaction during mixing?
   a. Use a chilled glass slab
   b. Use chilled components
   c. Add water to the liquid components
   d. Decrease the powder-to-liquid ratio
   e. Use incremental addition of powder to liquid

23. Fluoride release from silicate cement involves:
   a. Fluoride ion dissolution from particles and diffusion through the matrix
   b. Fluoride uptake from saliva and re-release at other times
   c. Hydrogen ion substitution from saliva for fluoride ion in the matrix
   d. Visible light acceleration of ionization of components in residual powder
   e. Precipitation of fluoride by calcium ions in saliva

24. The setting reaction of polycarboxylate cement creates which ONE of the following reaction products in the matrix?
   a. Zinc ethoxybenzoate
   b. Zinc eugenolate
   c. Tertiary zinc phosphate
   d. Zinc polyacrylate gel
   e. Calcium phosphate

25. Which one of the following acids have not been copolymerized into PCC liquid?
   a. Acrylic acid
   b. Maleic acid
   c. Itaconic acid
   d. Tartaric acid
   e. Phthallic acid

26. Traditional glass ionomer cements are a hybrid of:
   a. ZP and PCC
   b. SC and SPC
   c. ZOE-EBA and SC
   d. SC and PCC
   e. HV-EBA and ZP

27. The final reaction product matrix of a traditional GI cement is composed of:
   a. Ca acrylate gel
   b. Al acrylate gel
   c. Tertiary zinc phosphate
   d. Crystalline zinc ethoxybenzoate
   e. BIS-GMA polymer

28. Which one of the following does not include a glass ionomer reaction product?
   a. MM-GIC
   b. Compomer
   c. RM-GIC
   d. RR-GIC
   e. Giomer

29. Fluoride is released from glass ionomer cements by:
   a. Saliva reaction with residual glass particles
   b. Diffusion out of the matrix
   c. K and Na exchange reactions with CaF₂
   d. Secondary chemical reactions of saliva with the matrix
   e. Dissolution of fluoroapatite filler particles in the cement
30. After 1 week the typical fluoride release levels for a glass ionomer are:
   a. 20-25 ppm
   b. 15-20 ppm
   c. 10-15 ppm
   d.  5-10 ppm
   e.  1-2 ppm

31. Which one of the following vehicles can not be used to recharge glass ionomer cement?
   a. Toothpastes
   b. Mouthwashes
   c. Topical fluorides
   d. HF

32. Which of the following cement types is recommended for all-ceramic restorations?
   a. ZP
   b. CP
   c. RMGI
   d. PCC
   e. None of the above

33. Which additional component is required for silicate-based all-ceramic restorations?
   a. Silane coupling agent
   b. Diluent for composite
   c. Dual curing additive
   d. Flowable composite
   e. None of the above

34. How are silicate-based ceramic restorations prepared for bonding?
   a. Enamel bonding agent
   b. HF etching
   c. H₃PO₄ etching
   d. Wash and dry
   e. Nothing

35. How are silicate-based ceramic restorations prepared for bonding?
   a. Enamel bonding agent
   b. HF etching
   c. H₃PO₄ etching
   d. Wash and dry
   e. Nothing

36. Which one of the following is an example of a “universal cement”?
   a. Durelon
   b. Vitremer
   c. Fleck’s Mizzy
   d. UniCem
   e. Ketac Cem