

Name: \_\_\_\_\_

Date: \_\_\_\_\_



### Direction for Questions: 1 to 3

The following are some facts about a set of important p-group oxides.

- i) Silica is a colourless solid which melts at around 1700 °C; phosphorus pentoxide is a colourless solid melting at 420 °C; sulfur trioxide is a colourless gas which condenses to a liquid at about 45 °C and to a crystalline solid at about 17 °C.
- ii) At room temperature, silica is essentially insoluble in neutral water. However, both phosphorus pentoxide and sulfur trioxide dissolve violently and exothermically in neutral water.
- iii) Silica can be fused with potassium oxide to give potassium silicate, but the reaction is not violent. Both phosphorus pentoxide and sulfur trioxide react violently and exothermically with molten potassium oxide.
- iv) Living systems use the pyrophosphate linkage (P-O-P) for energy storage in the form of adenosine triphosphate (ATP), but the pyrosilicate (Si-O-Si) and pyrosulfate (S-O-S) linkages have not been encountered in living systems.

**Question: 1 of 17**

QID: 218

Marks: 6

Suggest an explanation for (i) in terms of the structures of the oxides. **(6 MARKS)**

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**Question: 2 of 17**

QID: 219

Marks: 6

Write equations for all of the reactions mentioned in (ii) and (iii) and comment on the energetics of each reaction. **(06 MARKS)**

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**Question: 3 of 17**

QID: 220

Marks: 4

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Suggest an explanation for (iv) in terms of your answers to the previous question. **(4 MARKS)**

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**Direction for Questions: 4 to 7**

At the dentist, the inorganic chemist is mostly interested by the composition of the visible part of the teeth, namely the dental crown.

Dental crown is made of two constituents: the enamel and the dentine. The enamel is the hard, white substance that covers the crown. This part is made of 97 to 99% hydroxyapatite,  $\text{Ca}_5(\text{PO}_4)_3\text{OH}$ . The crystals of this mineral are rather thin and long over the whole thickness of the enamel, which is about 2 mm.

The dentine (or the ivory of the teeth) is the inside part of the crown and the roots. It is made of 20% organic matter, 10% water and 70% hydroxyapatite. The crystals of the latter are shorter than those contained in the enamel. They have the form of needles, or plates, that are attached to each other in the organic matrix.

In the mouth, mineral substances such as calcium and phosphate ions that are present in saliva, contribute to the formation and the decomposition of hydroxyapatite. These two processes can occur simultaneously until an equilibrium is reached. The formation process is called mineralization or remineralization of the enamel, whereas the decomposition process is called demineralization.

**Question: 4 of 17**

QID: 214

Marks: 1

Write the balanced equation describing the mineralization and demineralization of tooth enamel in water.

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**Question: 5 of 17**

QID: 215

Marks: 2

Dental cavities, or the direct attack of dentine by organic acids and bacteria, is initiated by the demineralization process. The major cause of this process is the presence of dental plaque. The latter is a gelatinous mass of closely-packed microorganisms and polysaccharides attached to the tooth surface and maintained by the food particles that remain in the mouth. Improper dental hygiene will make the dental plaque thicker and it will become a good medium in which bacteria may grow. Under the plaque, near the enamel, anaerobic bacteria will decompose carbohydrates into organic acids such as acetic and lactic acids.

The natural lactic acid is levorotatory and possesses an R-configuration according to the Cahn-Ingold-Prelog rules.

On a rough paper, you may draw a three-dimensional structure of lactic acid. Then in the space provided here for your answer, and give a systematic (IUPAC) name of this acid.

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**Question: 6 of 17**

QID: 216

Marks: 7

The pH of the dental plaque can be significantly reduced by presence of acetic and lactic acids. If it goes below the critical value of pH 5.6 for a long period of time, an important demineralization process can occur and dental cavities will appear.

The influence of an acidic medium on the demineralization of teeth can be described by two different processes which depend on the ions produced by this reaction. Write the equations that correspond to each of these processes and explain their specific influence in the demineralization process.

**(7 MARKS)**

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**Question: 7 of 17**

QID: 217

Marks: 7

It is known that fluoride ions ensure a better protection for teeth. Two mechanisms are proposed to explain this phenomenon. First of all,

fluoride ions can inhibit the action of some enzymes such as those involved in the fermentation of the carbohydrates that produce the harmful organic acids. However, the major effect of the fluoride ions against the demineralization process is believed to occur during this process itself. Because their sizes are similar, the hydroxide ions of hydroxyapatite can be substituted by fluoride ions during the remineralization process to form a fluoroapatite,  $\text{Ca}_5(\text{PO}_4)_3\text{F}$ , which has a lower solubility.

Write the balanced equation for the reaction describing the decomposition and recombination of fluoroapatite in water. Calculate the solubilities of hydroxyapatite and fluoroapatite in water.

( $K_{\text{sp}}$  of hydroxyapatite =  $6.8 \times 10^{-37}$  and  $K_{\text{sp}}$  of fluoroapatite =  $1.0 \times 10^{-60}$ )

**(7 MARKS)**

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**Question: 8 of 17**

QID: 204

Marks: 1

The solubilities of carbonates decrease down the magnesium group (alkaline earth metals) due to a decrease in:

- A. lattice energies of solids
- B. hydration energies of cations
- C. inter-ionic attraction
- D. entropy of solution formation

**Question: 9 of 17**

QID: 205

Marks: 1

Which one of the following orders presents the correct sequence of the increasing basic nature of the given oxides?

- A.  $\text{K}_2\text{O} < \text{Na}_2\text{O} < \text{Al}_2\text{O}_3 < \text{MgO}$
- B.  $\text{Al}_2\text{O}_3 < \text{MgO} < \text{Na}_2\text{O} < \text{K}_2\text{O}$
- C.  $\text{MgO} < \text{K}_2\text{O} < \text{Al}_2\text{O}_3 < \text{Na}_2\text{O}$
- D.  $\text{MgO} < \text{K}_2\text{O} < \text{Na}_2\text{O} < \text{Al}_2\text{O}_3$

Question: 10 of 17

QID: 206

Marks: 1

Aqueous sodium hydroxide reacts with white phosphorous to form phosphine and \_\_\_\_\_ .

- A.  $\text{NaH}_2\text{PO}_2$                        B.  $\text{P}_2\text{O}_5$   
 C.  $\text{Na}_2\text{PO}_3$                        D.  $\text{P}_2\text{O}_3$

Question: 11 of 17

QID: 207

Marks: 1

In organic reactions, sodium in liquid ammonia is used as ....

- A. Reducing agent                       B. Hydrolyzing agent  
 C. Oxidizing agent                       D. Precipitating agent

Question: 12 of 17

QID: 208

Marks: 1

Which of the following compounds is expected to be colored?

- A.  $\text{Ag}_2\text{SO}_4$                        B.  $\text{CuF}_2$   
 C.  $\text{MgF}_2$                        D.  $\text{CuCl}$

Question: 13 of 17

QID: 209

Marks: 1

Amongst the following, identify the species with an atom in oxidation state +6.

- A.  $\text{MnO}_4^-$                        B.  $\text{Cr}(\text{CN})_6^{3-}$   
 C.  $\text{NiF}_6^{2-}$                        D.  $\text{CrO}_2\text{Cl}_2$

Question: 14 of 17

QID: 210

Marks: 1

Electrolytic reduction of alumina to aluminium by Hall - Heroult process is carried out

- A. In the presence of cryolite which forms a melt with higher melting temperature                       B. In the presence of fluorite  
 C. In the presence of cryolite which forms a melt with lower melting temperature                       D. In the presence of NaCl

Question: 15 of 17

QID: 211

Marks: 1

Who presented the law of octave?

- A. Dobereiner
- B. Newlands
- C. Lothar Meyer
- D. Mendeleeff

Question: 16 of 17

QID: 212

Marks: 1

Among the alkaline earth metals, the element forming predominantly covalent compound is

- A. Be
- B. Mg
- C. Sr
- D. Ca

Question: 17 of 17

QID: 213

Marks: 1

A solution of sodium in liquid ammonia is blue due to the presence of:

- A. Na atoms
- B. Ammonium ions
- C. Solvated Na<sup>+</sup> ions
- D. Solvated electrons

--- END OF QUESTION PAPER ---