

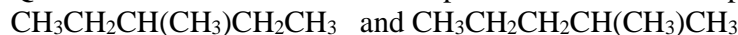
**PART I (7.0 points)**

Write the correct answer (A, B, C or D) for each of the following questions in the correspondingly numbered space on your answer sheet.

**Question 1.** Which of the following is a chemical change?

- A. Dissolution of table salt in water.      B. Boiling of water.  
C. Rusting of iron.      D. Freezing of water.

**Question 2.** What is the relationship between the two compounds below?



- A. Identical compounds.      B. Structural constitutional isomers.  
C. Geometric isomers.      D. Stereoisomers.

**Question 3.** Which element does NOT have multiple allotropes?

- A. Oxygen.      B. Fluorine.      C. Carbon.      D. Phosphorus.

**Question 4.** An alkane contains 14 hydrogen atoms. How many carbon atoms does it contain?

- A. 6.      B. 5.      C. 30.      D. 8.

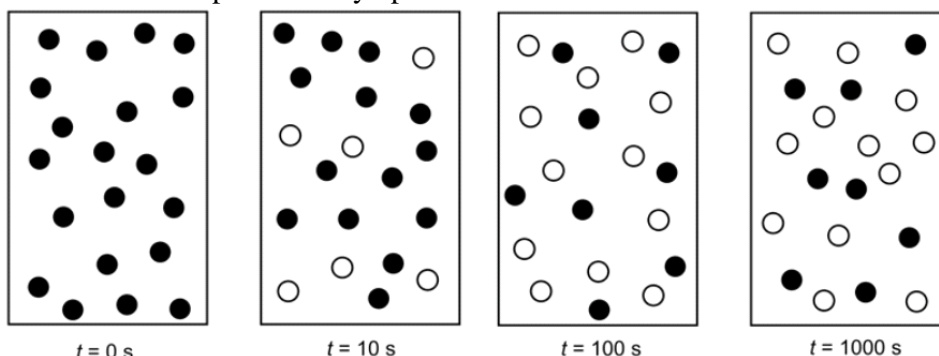
**Question 5.** What is the mass number of an atom which contains 14 protons, 14 electrons, and 15 neutrons?

- A. 14.      B. 28.      C. 43.      D. 29.

**Question 6.** A pH greater than 7 indicates

- A. alkalinity.      B. purity of the sample.      C. presence of ions.      D. acidity.

**Question 7.** The diagrams below represent the progress of a reaction of  $\text{A} \rightarrow \text{B}$ , with molecules of A represented by solid circles and molecules of B represented by open circles. Which statement best describes the reaction at  $t = 1000 \text{ s}$ ?



- A. The reaction is not at equilibrium because not all of A has been consumed.  
B. The reaction is not at equilibrium because the positions of the molecules are still changing.  
C. The reaction is at equilibrium because the concentrations of A and B are no longer changing.  
D. The reaction is not at equilibrium because the concentrations of A and B are not equal.

**Question 8.** Which hydrocarbon is 84.2% carbon by mass?

- A.  $\text{C}_4\text{H}_{10}$ .      B.  $\text{CH}_4$ .      C.  $\text{C}_8\text{H}_{18}$ .      D.  $\text{C}_2\text{H}_6$ .

**Question 9.** The phase transition from solid to gas without passing through the liquid state is called

- A. sublimation.      B. boiling.      C. melting.      D. condensation.

**Question 10.** A gas phase atom with an atomic number of 26 loses three electrons. What is the electron configuration of the resulting gas phase ion?

- A.  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$ .      B.  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^4 4s^1$ .      C.  $1s^2 2s^2 2p^6 3s^2 3p^5 3d^5 4s^1$ .      D.  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3 4s^2$ .

**Question 11.** How many  $\sigma$  and  $\pi$  bonds are in 1,3-butadiene,  $\text{H}_2\text{C}=\text{CH}-\text{CH}=\text{CH}_2$ ?

- A. 7  $\sigma$  and 2  $\pi$  bonds.      B. 2  $\sigma$  and 7  $\pi$  bonds.      C. 2  $\sigma$  and 9  $\pi$  bonds.      D. 9  $\sigma$  and 2  $\pi$  bonds.

**Question 12.** Choose the most correct definition.

- A. Organic compounds are based on carbon, and they usually contain carbon-nitrogen and carbon-silicon bonds.  
B. Organic compounds are based on nitrogen, and they usually contain carbon-nitrogen and carbon-hydrogen bonds.  
C. Organic compounds are based on hydrogen, and they usually contain carbon-hydrogen and carbon-oxygen bonds.

D. Organic compounds are based on carbon, and they usually contain carbon-hydrogen and carbon-carbon bonds.

**Question 13.** A white ionic solid is dissolved in water. Addition of a solution of sodium chloride to this solution results in a white precipitate. What was the cation in the original ionic solid?

- A.  $\text{Ca}^{2+}$ .                      B.  $\text{Na}^+$ .                      C.  $\text{Fe}^{3+}$ .                      D.  $\text{Ag}^+$ .

**Question 14.** Which set of properties best describes a small alkane, such as ethane?

- A. polar, low boiling point, soluble in water, not very reactive.  
B. polar, high boiling point, insoluble in water, extremely reactive.  
C. non-polar, high boiling point, insoluble in water, extremely reactive.  
D. non-polar, low boiling point, insoluble in water, not very reactive.

**Question 15.** Which of the following is true?

- A. Reduction is the gain of electrons and the increase in oxidation number.  
B. Reduction is the loss of electrons and the increase in oxidation number.  
C. Reduction is the loss of electrons and the decrease in oxidation number.  
D. Reduction is the gain of electrons and the decrease in oxidation number.

**Question 16.** How many hydroxide ions are in 2.5 mol  $\text{Mg}(\text{OH})_2$ ?

- A.  $6.0 \times 10^{23}$ .                      B.  $1.5 \times 10^{24}$ .                      C.  $3.0 \times 10^{24}$ .                      D.  $3.0 \times 10^{23}$ .

**Question 17.** Which combination of atoms can form a non-polar covalent bond?

- A. Na and Br.                      B. N and Mg.                      C. O and O.                      D. H and Cl.

**Question 18.** Which of the following solutions ( $C = 0.1 \text{ mol/L}$ ) has the highest pH value?

- A. ammonia.                      B. potassium hydroxide.                      C. acetic acid.                      D. hydrochloric acid.

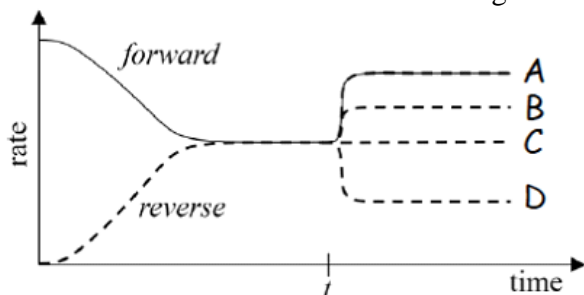
**Question 19.** When a solution of barium hydroxide is mixed with a solution of copper (II) nitrate, what is observed?

- A. Evolution of a colorless gas.                      B. Precipitation of a colored solid.  
C. Neither precipitation nor gas evolution.                      D. Precipitation of a colorless solid.

**Question 20.** The oxidation number of carbon in a compound cannot be

- A. +4.                      B. +2.                      C. -4.                      D. +6.

**Question 21.** The graph below shows the forward and reverse rates for a reaction as a function of time. At time  $t$ , a catalyst is added to the system, and the forward reaction rate is observed to change as indicated by the solid curve. Which dashed curve best indicates how the reverse reaction rate changes?



- A. D.                      B. A.                      C. B.                      D. C.

**Question 22.** Which is the best way to prepare 500 mL of a 2.00 M solution of aqueous  $\text{H}_2\text{SO}_4$  from deionized water (density =  $1.00 \text{ g/mL}$ ) and concentrated  $\text{H}_2\text{SO}_4$  (density =  $1.84 \text{ g/mL}$ )?

A. Weigh 98.1 g concentrated sulfuric acid into a 100-mL beaker, then slowly pour the  $\text{H}_2\text{SO}_4$  into a 500-mL beaker with about 250 mL deionized water in it. Pour this solution into a 500-mL volumetric flask and fill to the mark with deionized water and mix.

B. Weigh 98.1 g concentrated sulfuric acid into a 500-mL volumetric flask, slowly add deionized water to the mark, and mix.

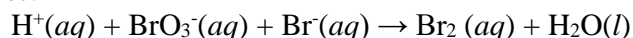
C. Weigh 98.1 g concentrated sulfuric acid into a 500-mL beaker, then slowly add deionized water to the beaker, with occasional swirling, until the liquid reaches the 500 mL mark.

D. Weigh 446.6 g deionized water into a 500-mL volumetric flask, fill to the mark with concentrated sulfuric acid, and mix.

**Question 23.** Which one of the following sets of ions can coexist at large in an aqueous solution?

- A.  $\text{NH}_4^+$ ,  $\text{HCO}_3^-$ ,  $\text{OH}^-$ .                      B.  $\text{Ba}^{2+}$ ,  $\text{Cu}^{2+}$ ,  $\text{SO}_4^{2-}$ .                      C.  $\text{Na}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{NO}_3^-$ .                      D.  $\text{Ag}^+$ ,  $\text{H}^+$ ,  $\text{Cl}^-$ .

**Question 24.** Bromate ion and bromide ion react to form bromine in acidic solution. When the reaction is balanced, which statement about  $\text{H}^+ (aq)$  is correct?



- A. Its coefficient is twice the coefficient of  $\text{Br}^-(aq)$ .  
B. Its coefficient is twice the coefficient of  $\text{Br}_2(aq)$ .

C. Its coefficient is twice the coefficient of  $\text{BrO}_3^-(aq)$ .

D. Its coefficient is the sum of the coefficients of  $\text{BrO}_3^-(aq)$  and  $\text{H}_2\text{O}(l)$ .

**Question 25.** A test tube contains a clear, colourless salt solution. A few drops of silver nitrate solution are added to the solution and a pale yellow precipitate forms. Which one of the following salts was dissolved in the original solution?

A.  $\text{K}_2\text{SO}_4$ .

B.  $\text{KI}$ .

C.  $\text{Na}_2\text{CO}_3$ .

D.  $\text{NaCl}$ .

**Question 26.** A 5.0 g sample of calcium nitrate ( $\text{Ca}(\text{NO}_3)_2$ ) contaminated with silica ( $\text{SiO}_2$ ) is found to contain 1.0 g calcium. What is the mass percent purity of calcium nitrate in the sample?

A. 73%.

B. 82%.

C. 24%.

D. 20%.

**Question 27.** A 10.00 g sample of a compound containing only carbon, hydrogen and oxygen forms 23.98 g  $\text{CO}_2$  and 4.91 g  $\text{H}_2\text{O}$  upon complete combustion. What is the empirical formula of the compound?

A.  $\text{C}_3\text{H}_3\text{O}$ .

B.  $\text{C}_6\text{H}_6\text{O}$ .

C.  $\text{C}_2\text{HO}$ .

D.  $\text{C}_6\text{H}_3\text{O}_2$ .

**Question 28.** A sample of lemon juice has a pH of 2. A sample of an ammonia cleaner has a pH of 11. If the two samples are combined, what ratio by volume of lemon juice to ammonia cleaner is needed to yield a neutral solution?

A. 1 : 10.

B. 1 : 100.

C. 1 : 1000.

D. 10 : 1.

**Question 29.** A 2.5 L sample of butane gas ( $\text{C}_4\text{H}_{10}$ ), measured at  $22.0^\circ\text{C}$  and 1.20 atm pressure, is combusted completely and the carbon dioxide gas is collected at the same pressure and temperature. What volume of  $\text{CO}_2$  is produced?

A. 2.5 L.

B. 9.0 L.

C. 22.5 L.

D. 10.0 L.

**Question 30.**  $\text{C}(s) + \text{H}_2\text{O}(g) \rightleftharpoons \text{CO}(g) + \text{H}_2(g) \quad \Delta H > 0$

For the system above at equilibrium, which changes will increase the amount of  $\text{H}_2(g)$ ?

I. Adding  $\text{C}(s)$

II. Increasing the volume of the container

III. Increasing the temperature

A. I, II and III.

B. I only.

C. II and III only.

D. III only.

**Question 31.** Desiccated anhydrous calcium chloride was stored in an improperly closed vessel. Thus it was partially hydrated again. A 150 g sample of this material was completely dissolved in 80 g of hot water, then the solution was cooled down to  $20^\circ\text{C}$ . On cooling, 40.9 g of  $\text{CaCl}_2 \cdot 6\text{H}_2\text{O}$  precipitated. Solubility of calcium chloride at  $20^\circ\text{C}$  is 74.5 g of  $\text{CaCl}_2/100$  g of water. Determine the water content of calcium chloride in the 150 g sample (moles of water per 1 mole of  $\text{CaCl}_2$ ).

A. 2.70.

B. 3.09.

C. 2.54.

D. 2.95.

**Question 32.** A 12.2 g sample containing rock salt ( $\text{NaCl}$ ) and sylvinit ( $\text{KCl} \cdot \text{NaCl}$ ) was dissolved in 100 mL of water. After the insoluble impurities were removed by filtering, the solution had a volume of 104 mL. A 10.0 mL aliquot of this solution was added to an excess of acidified aqueous silver nitrate. The resulting precipitate was filtered, dried, and weighed. Its mass was found to be 2.53 g. Another 5.00 mL aliquot of the solution was evaporated to dryness to yield 0.543 g of a solid residue. The mass percentage of  $\text{KCl} \cdot \text{NaCl}$  in the sample is

A. 45.4%.

B. 62.0%.

C. 38.0%.

D. 38.2%.

**Question 33.** A student wishes to prepare a solution with a final concentration of  $\text{Na}^+ = 0.50 \text{ M}$  and a final concentration of  $\text{HCO}_3^- = 0.10 \text{ M}$  by taking some  $\text{NaOH}$  and some trona ( $\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$ ) and diluting with water to a final volume of 1.00 L. How much  $\text{NaOH}$  and trona are required?

A. 0.05 mol  $\text{NaOH}$ , 0.15 mol trona.

B. 0.35 mol  $\text{NaOH}$ , 0.05 mol trona.

C. 0.20 mol  $\text{NaOH}$ , 0.10 mol trona.

D. A solution cannot be prepared with the desired concentration of  $\text{Na}^+$  and  $\text{HCO}_3^-$  using only  $\text{NaOH}$  and trona.

**Question 34.** You know that salty water is particularly healthy and you want to raise the mass content of chloride in the pool water to 1%. 1 kg of pure salt costs 3500 VND. The pool has a base area of 5m x 6m and is filled up to 1.8m. The density of the water delivered by the company amounts to 1 g/cm<sup>3</sup>. Assume an original mass content of 25 mg of chloride/100 mL of water. The expense to reach the wanted mass concentration by adding pure salt is

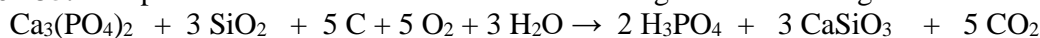
A. 2.36 million VND.

B. 3.09 million VND.

C. 2.41 million VND.

D. 1.86 million VND.

**Question 35.** Phosphoric acid can be manufactured according to the following reaction:



If equal masses of calcium phosphate and silica are reacted with excess carbon, oxygen and water to produce  $1.00 \times 10^3$  kg phosphoric acid, what mass of calcium phosphate was used, assuming 100% yield?

A. 1581.6 kg.

B. 3163.3 kg.

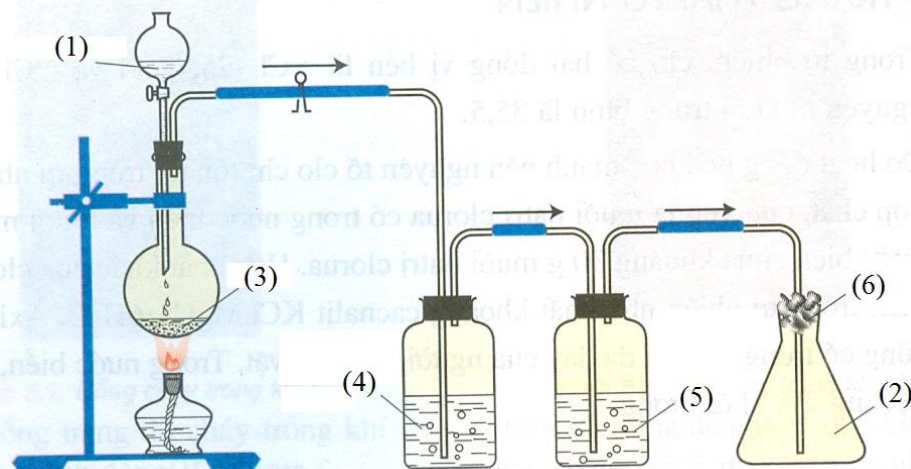
C. 1583.2 kg.

D. 1054.4 kg.

## PART II (3.0 points)

Write the solutions to the following questions in the provided space on your answer sheet.

**Question 1.** The following picture shows the experiment to prepare  $\text{Cl}_2$  in the lab.



1. Write a balanced equation to prepare  $\text{Cl}_2$  in the lab.

2. What are the names of the chemicals used in position (1), (2), (3), (4), (5), (6)?

### Question 2.

1. A 1.92 L sample (at STP) of a gaseous mixture of hydrocarbons that is 12.6% elemental hydrogen (by mass) was burnt in an excess of oxygen. The volatile combustion products were dried and bubbled through 400 mL of a 4.82% (by mass) NaOH solution with a density of  $1.05 \text{ g/cm}^3$ .

- Calculate the initial mass of the hydrocarbon mixture given that its specific gravity relative to nitrogen is 2.27.
- What volume is occupied by the resulting carbon dioxide at N.T.P
- Determine the qualitative composition and mass percentage of substances in the solution obtained by bubbling the carbon dioxide gas through the NaOH solution.

2. Explain and describe what happens when the excess of carbon dioxide gas is slowly bubbled through limewater.

### Question 3.

1. A beaker with 12.00 g of  $\text{CuSO}_4$  was set aside on vacation. One week later, precisely  $\frac{1}{3}$  of the salt transformed into pentahydrate ( $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ ). 90.00  $\text{cm}^3$  of water was casually sloshed into the beaker during cleanup after vacation. After that all the charge was transferred into a flask filled with 300.0  $\text{cm}^3$  0.0400 M NaOH solution. A formed precipitate was separated and heated until a black substance was formed and its mass remained stable. Assuming the density of water is  $1 \text{ g/cm}^3$ .

- Calculate the percentage of  $\text{CuSO}_4$  in the formed solution after adding water.
- Write all the reactions taking place and name the compounds that contain copper. Calculate the mass of the substance after heating.

2. A sample of gaseous hydrocarbon occupying 5.377 litres at N.T.P completely burnt in air produced 19.712 grams of  $\text{CO}_2$  and 8.064 grams of  $\text{H}_2\text{O}$ . Find the molecular formula and draw the electron formula of the hydrocarbon.

*Note: N.T.P - Normal Temperature and Pressure - is defined as gas at  $20^\circ\text{C}$  and 1 atm.*

*S.T.P – Standard Temperature and Pressure - is defined as gas at  $0^\circ\text{C}$  and 1 atm.*

**-THE END-**

Student's full name: .....

Student's ID: .....

First observer's name and signature: .....

Second observer's name and signature: .....

**PART I (7.0 points)**

Write the correct answer (A, B, C or D) for each of the following questions in the correspondingly numbered space on your answer sheet.

**Question 1.** Which hydrocarbon is 84.2% carbon by mass?

- A. CH<sub>4</sub>.                      B. C<sub>4</sub>H<sub>10</sub>.                      C. C<sub>2</sub>H<sub>6</sub>.                      D. C<sub>8</sub>H<sub>18</sub>.

**Question 2.** A gas phase atom with an atomic number of 26 loses three electrons. What is the electron configuration of the resulting gas phase ion?

- A. 1s<sup>2</sup>2s<sup>2</sup>2p<sup>6</sup>3s<sup>2</sup>3p<sup>6</sup>3d<sup>5</sup>.      B. 1s<sup>2</sup>2s<sup>2</sup>2p<sup>6</sup>3s<sup>2</sup>3p<sup>6</sup>3d<sup>3</sup>4s<sup>2</sup>.      C. 1s<sup>2</sup>2s<sup>2</sup>2p<sup>6</sup>3s<sup>2</sup>3p<sup>5</sup>3d<sup>5</sup>4s<sup>1</sup>.      D. 1s<sup>2</sup>2s<sup>2</sup>2p<sup>6</sup>3s<sup>2</sup>3p<sup>6</sup>3d<sup>4</sup>4s<sup>1</sup>.

**Question 3.** When a solution of barium hydroxide is mixed with a solution of copper (II) nitrate, what is observed?

- A. Precipitation of a colored solid.                      B. Neither precipitation nor gas evolution.  
C. Precipitation of a colorless solid.                      D. Evolution of a colorless gas.

**Question 4.** The phase transition from solid to gas without passing through the liquid state is called

- A. boiling.                      B. condensation.                      C. sublimation.                      D. melting.

**Question 5.** An alkane contains 14 hydrogen atoms. How many carbon atoms does it contain?

- A. 5.                      B. 30.                      C. 8.                      D. 6.

**Question 6.** Which of the following is a chemical change?

- A. Dissolution of table salt in water.                      B. Boiling of water.  
C. Rusting of iron.                      D. Freezing of water.

**Question 7.** Which set of properties best describes a small alkane, such as ethane?

- A. polar, low boiling point, soluble in water, not very reactive.  
B. polar, high boiling point, insoluble in water, extremely reactive.  
C. non-polar, low boiling point, insoluble in water, not very reactive.  
D. non-polar, high boiling point, insoluble in water, extremely reactive.

**Question 8.** Which of the following is true?

- A. Reduction is the gain of electrons and the increase in oxidation number.  
B. Reduction is the loss of electrons and the increase in oxidation number.  
C. Reduction is the loss of electrons and the decrease in oxidation number.  
D. Reduction is the gain of electrons and the decrease in oxidation number.

**Question 9.** What is the mass number of an atom which contains 14 protons, 14 electrons, and 15 neutrons?

- A. 43.                      B. 14.                      C. 29.                      D. 28.

**Question 10.** A white ionic solid is dissolved in water. Addition of a solution of sodium chloride to this solution results in a white precipitate. What was the cation in the original ionic solid?

- A. Ag<sup>+</sup>.                      B. Na<sup>+</sup>.                      C. Ca<sup>2+</sup>.                      D. Fe<sup>3+</sup>.

**Question 11.** How many σ and π bonds are in 1,3-butadiene, H<sub>2</sub>C=CH-CH=CH<sub>2</sub>?

- A. 2 σ and 9 π bonds.      B. 2 σ and 7 π bonds.      C. 9 σ and 2 π bonds.      D. 7 σ and 2 π bonds.

**Question 12.** Which combination of atoms can form a non-polar covalent bond?

- A. H and Cl.                      B. Na and Br.                      C. N and Mg.                      D. O and O.

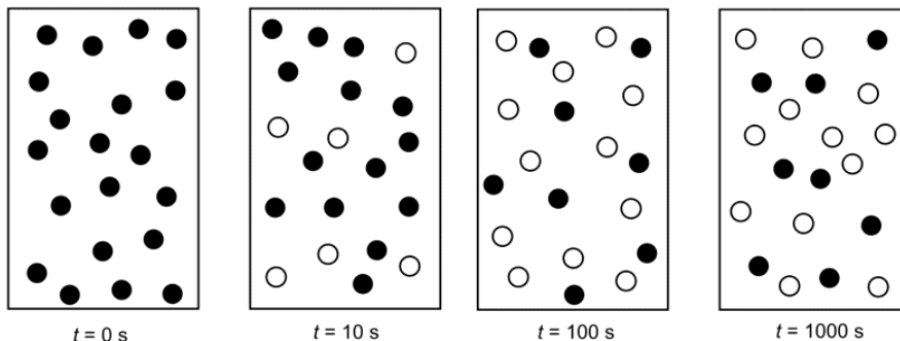
**Question 13.** Choose the most correct definition.

- A. Organic compounds are based on hydrogen, and they usually contain carbon- hydrogen and carbon-oxygen bonds.  
B. Organic compounds are based on carbon, and they usually contain carbon-nitrogen and carbon-silicon bonds.  
C. Organic compounds are based on carbon, and they usually contain carbon- hydrogen and carbon-carbon bonds.  
D. Organic compounds are based on nitrogen, and they usually contain carbon-nitrogen and carbon-hydrogen bonds.

**Question 14.** Which element does NOT have multiple allotropes?

- A. Carbon.                      B. Fluorine.                      C. Oxygen.                      D. Phosphorus.

**Question 15.** The diagrams below represent the progress of a reaction of A → B, with molecules of A represented by solid circles and molecules of B represented by open circles. Which statement best describes the reaction at t = 1000s?



- A. The reaction is not at equilibrium because not all of A has been consumed.  
 B. The reaction is not at equilibrium because the positions of the molecules are still changing.  
 C. The reaction is not at equilibrium because the concentrations of A and B are not equal.  
 D. The reaction is at equilibrium because the concentrations of A and B are no longer changing.

**Question 17.** The oxidation number of carbon in a compound cannot be

- A. +4. B. -4. C. +2. D. +6.

**Question 18.** Which of the following solutions (C = 0.1 mol/L) has the highest pH value?

- A. ammonia. B. acetic acid. C. potassium hydroxide. D. hydrochloric acid.

**Question 19.** What is the relationship between the two compounds below?

$\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$  and  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_3$

- A. Structural constitutional isomers. B. Geometric isomers.  
 C. Stereoisomers. D. Identical compounds.

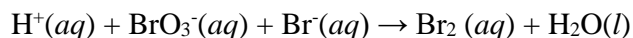
**Question 20.** A pH greater than 7 indicates

- A. presence of ions. B. acidity. C. purity of the sample. D. alkalinity.

**Question 21.** A test tube contains a clear, colourless salt solution. A few drops of silver nitrate solution are added to the solution and a pale yellow precipitate forms. Which one of the following salts was dissolved in the original solution?

- A. KI. B.  $\text{Na}_2\text{CO}_3$ . C. NaCl. D.  $\text{K}_2\text{SO}_4$ .

**Question 22.** Bromate ion and bromide ion react to form bromine in acidic solution. When the reaction is balanced, which statement about  $\text{H}^+$  (aq) is correct?



- A. Its coefficient is twice the coefficient of  $\text{BrO}_3^-(\text{aq})$ .  
 B. Its coefficient is the sum of the coefficients of  $\text{BrO}_3^-(\text{aq})$  and  $\text{H}_2\text{O}(\text{l})$ .  
 C. Its coefficient is twice the coefficient of  $\text{Br}_2(\text{aq})$ .  
 D. Its coefficient is twice the coefficient of  $\text{Br}^-(\text{aq})$ .

**Question 23.** Which is the best way to prepare 500 mL of a 2.00 M solution of aqueous  $\text{H}_2\text{SO}_4$  from deionized water (density =  $1.00 \text{ g.mL}^{-1}$ ) and concentrated  $\text{H}_2\text{SO}_4$  (density =  $1.84 \text{ g.mL}^{-1}$ )?

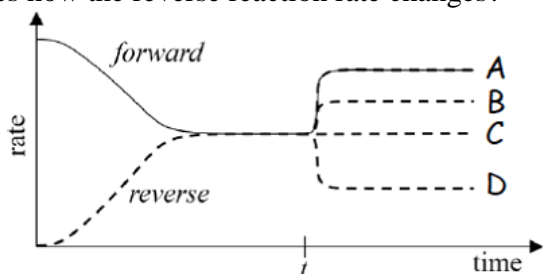
A. Weigh 98.1 g concentrated sulfuric acid into a 500-mL beaker, then slowly add deionized water to the beaker, with occasional swirling, until the liquid reaches the 500 mL mark.

B. Weigh 98.1 g concentrated sulfuric acid into a 100-mL beaker, then slowly pour the  $\text{H}_2\text{SO}_4$  into a 500-mL beaker with about 250 mL deionized water in it. Pour this solution into a 500-mL volumetric flask and fill to the mark with deionized water and mix.

C. Weigh 446.6 g deionized water into a 500-mL volumetric flask, fill to the mark with concentrated sulfuric acid, and mix.

D. Weigh 98.1 g concentrated sulfuric acid into a 500-mL volumetric flask, slowly add deionized water to the mark, and mix.

**Question 24.** The graph below shows the forward and reverse rates for a reaction as a function of time. At time t, a catalyst is added to the system, and the forward reaction rate is observed to change as indicated by the solid curve. Which dashed curve best indicates how the reverse reaction rate changes?



- A. A. B. B. C. D. D. C.



**Question 25.** Which one of the following sets of ions can coexist at large in an aqueous solution?

- A.  $\text{NH}_4^+$ ,  $\text{HCO}_3^-$ ,  $\text{OH}^-$ .      B.  $\text{Na}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{NO}_3^-$ .      C.  $\text{Ba}^{2+}$ ,  $\text{Cu}^{2+}$ ,  $\text{SO}_4^{2-}$ .      D.  $\text{Ag}^+$ ,  $\text{H}^+$ ,  $\text{Cl}^-$ .

**Question 26.**  $\text{C(s)} + \text{H}_2\text{O(g)} \rightleftharpoons \text{CO(g)} + \text{H}_2\text{(g)} \quad \Delta H > 0$

For the system above at equilibrium, which changes will increase the amount of  $\text{H}_2\text{(g)}$ ?

- I. Adding  $\text{C(s)}$   
II. Increasing the volume of the container  
III. Increasing the temperature

- A. III only.      B. II and III only.      C. I only.      D. I, II and III.

**Question 27.** A 5.0 g sample of calcium nitrate ( $\text{Ca(NO}_3)_2$ ) contaminated with silica ( $\text{SiO}_2$ ) is found to contain 1.0 g calcium. What is the mass percent purity of calcium nitrate in the sample?

- A. 73%.      B. 24%.      C. 20%.      D. 82%.

**Question 28.** A sample of lemon juice has a pH of 2. A sample of an ammonia cleaner has a pH of 11. If the two samples are combined, what ratio by volume of lemon juice to ammonia cleaner is needed to yield a neutral solution?

- A. 1 : 100.      B. 1 : 1000.      C. 10 : 1.      D. 1 : 10.

**Question 29.** A 10.00 g sample of a compound containing only carbon, hydrogen and oxygen forms 23.98 g  $\text{CO}_2$  and 4.91 g  $\text{H}_2\text{O}$  upon complete combustion. What is the empirical formula of the compound?

- A.  $\text{C}_6\text{H}_3\text{O}_2$ .      B.  $\text{C}_3\text{H}_3\text{O}$ .      C.  $\text{C}_6\text{H}_6\text{O}$ .      D.  $\text{C}_2\text{HO}$ .

**Question 30.** A 2.5 L sample of butane gas ( $\text{C}_4\text{H}_{10}$ ), measured at  $22.0^\circ\text{C}$  and 1.20 atm pressure, is combusted completely and the carbon dioxide gas is collected at the same pressure and temperature. What volume of  $\text{CO}_2$  is produced?

- A. 2.5 L.      B. 9.0 L.      C. 10.0 L.      D. 22.5 L.

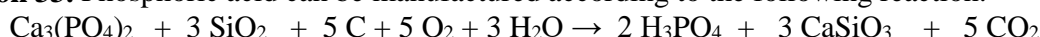
**Question 31.** A 12.2 g sample containing rock salt ( $\text{NaCl}$ ) and sylvinit ( $\text{KCl.NaCl}$ ) was dissolved in 100 mL of water. After the insoluble impurities were removed by filtering, the solution had a volume of 104 mL. A 10.0 mL aliquot of this solution was added to an excess of acidified aqueous silver nitrate. The resulting precipitate was filtered, dried, and weighed. Its mass was found to be 2.53 g. Another 5.00 mL aliquot of the solution was evaporated to dryness to yield 0.543 g of a solid residue. The mass percentage of  $\text{KCl.NaCl}$  in the sample is

- A. 45.4%.      B. 38.0%.      C. 38.2%.      D. 62.0%.

**Question 32.** Descalcified anhydrous calcium chloride was stored in an improperly closed vessel. Thus it was partially hydrated again. A 150 g sample of this material was completely dissolved in 80 g of hot water, then the solution was cooled down to  $20^\circ\text{C}$ . On cooling, 40.9 g of  $\text{CaCl}_2 \cdot 6\text{H}_2\text{O}$  precipitated. Solubility of calcium chloride at  $20^\circ\text{C}$  is 74.5 g of  $\text{CaCl}_2/100$  g of water. Determine the water content of calcium chloride in the 150 g sample (moles of water per 1 mole of  $\text{CaCl}_2$ ).

- A. 2.95.      B. 2.54.      C. 2.70.      D. 3.09.

**Question 33.** Phosphoric acid can be manufactured according to the following reaction:



If equal masses of calcium phosphate and silica are reacted with excess carbon, oxygen and water to produce  $1.00 \times 10^3$  kg phosphoric acid, what mass of calcium phosphate was used, assuming 100% yield?

- A. 3163.3 kg.      B. 1583.2 kg.      C. 1581.6 kg.      D. 1054.4 kg.

**Question 34.** A student wishes to prepare a solution with a final concentration of  $\text{Na}^+ = 0.50 \text{ M}$  and a final concentration of  $\text{HCO}_3^- = 0.10 \text{ M}$  by taking some  $\text{NaOH}$  and some trona ( $\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$ ) and diluting with water to a final volume of 1.00 L. How much  $\text{NaOH}$  and trona are required?

- A. 0.20 mol  $\text{NaOH}$ , 0.10 mol trona.  
B. 0.05 mol  $\text{NaOH}$ , 0.15 mol trona.  
C. A solution cannot be prepared with the desired concentration of  $\text{Na}^+$  and  $\text{HCO}_3^-$  using only  $\text{NaOH}$  and trona.  
D. 0.35 mol  $\text{NaOH}$ , 0.05 mol trona.

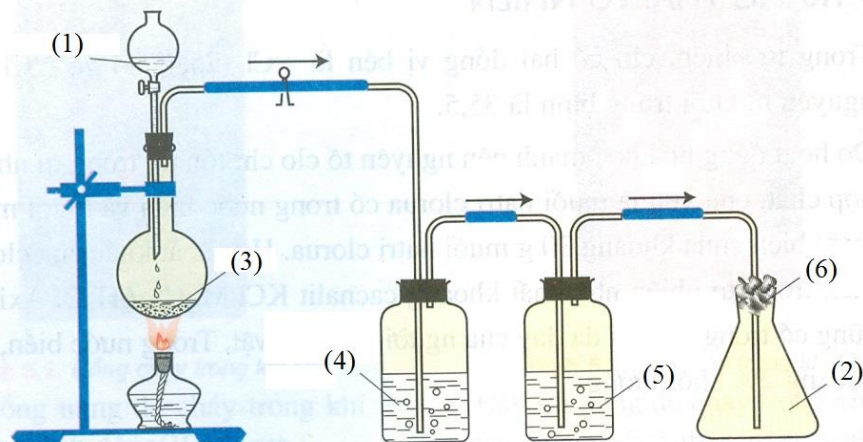
**Question 35.** You know that salty water is particularly healthy and you want to raise the mass content of chloride in the pool water to 1%. 1 kg of pure salt costs 3500 VND. The pool has a base area of 5m x 6m and is filled up to 1.8m. The density of the water delivered by the company amounts to  $1 \text{ g/cm}^3$ . Assume an original mass content of 25 mg of chloride/100 mL of water. The expense to reach the wanted mass concentration by adding pure salt is

- A. 3.09 million VND.      B. 2.41 million VND.      C. 2.36 million VND.      D. 1.86 million VND.

## PART II (3.0 points)

Write the solutions to the following questions in the provided space on your answer sheet.

**Question 1.** The following picture shows the experiment to prepare  $\text{Cl}_2$  in the lab.



1. Write a balanced equation to prepare  $\text{Cl}_2$  in the lab.
2. What are the names of the chemicals used in position (1), (2), (3), (4), (5), (6)?

### Question 2.

1. A 1.92 L sample (at STP) of a gaseous mixture of hydrocarbons that is 12.6% elemental hydrogen (by mass) was burnt in an excess of oxygen. The volatile combustion products were dried and bubbled through 400 mL of a 4.82% (by mass) NaOH solution with a density of  $1.05 \text{ g/cm}^3$ .
  - a. Calculate the initial mass of the hydrocarbon mixture given that its specific gravity relative to nitrogen is 2.27.
  - b. What volume is occupied by the resulting carbon dioxide at N.T.P
  - c. Determine the qualitative composition and mass percentage of substances in the solution obtained by bubbling the carbon dioxide gas through the NaOH solution.
2. Explain and describe what happens when the excess of carbon dioxide gas is slowly bubbled through limewater.

### Question 3.

1. A beaker with 12.00 g of  $\text{CuSO}_4$  was set aside on vacation. One week later, precisely  $\frac{1}{3}$  of the salt transformed into pentahydrate ( $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ ). 90.00  $\text{cm}^3$  of water was casually slooshed into the beaker during cleanup after vacation. After that all the charge was transferred into a flask filled with 300.0  $\text{cm}^3$  0.0400 M NaOH solution. A formed precipitate was separated and heated until a black substance was formed and its mass remained stable. Assuming the density of water is  $1 \text{ g/cm}^3$ .
  - a. Calculate the percentage of  $\text{CuSO}_4$  in the formed solution after adding water.
  - b. Write all the reactions taking place and name the compounds that contain copper. Calculate the mass of the substance after heating.
2. A sample of gaseous hydrocarbon occupying 5.377 litres at N.T.P completely burnt in air produced 19.712 grams of  $\text{CO}_2$  and 8.064 grams of  $\text{H}_2\text{O}$ . Find the molecular formula and draw the electron formula of the hydrocarbon.

*Note: N.T.P - Normal Temperature and Pressure - is defined as gas at  $20^\circ\text{C}$  and 1 atm.*

*S.T.P – Standard Temperature and Pressure - is defined as gas at  $0^\circ\text{C}$  and 1 atm.*

**-THE END-**

Student's full name: .....

Student's ID: .....

First observer's name and signature: .....

Second observer's name and signature: .....



**PART I (7.0 points)**

Write the correct answer (A, B, C or D) for each of the following questions in the correspondingly numbered space on your answer sheet.

**Question 1.** Which of the following is true?

- A. Reduction is the loss of electrons and decrease in oxidation number.
- B. Reduction is the loss of electrons and increase in oxidation number.
- C. Reduction is the gain of electrons and decrease in oxidation number.
- D. Reduction is the gain of electrons and increase in oxidation number.

**Question 2.** How many hydroxide ions are in 2.5 mol  $\text{Mg}(\text{OH})_2$ ?

- A.  $6.0 \times 10^{23}$ .
- B.  $3.0 \times 10^{23}$ .
- C.  $1.5 \times 10^{24}$ .
- D.  $3.0 \times 10^{24}$ .

**Question 3.** An alkane contains 14 hydrogen atoms. How many carbon atoms does it contain?

- A. 30.
- B. 6.
- C. 5.
- D. 8.

**Question 4.** Which element does NOT have multiple allotropes?

- A. Fluorine.
- B. Carbon.
- C. Oxygen.
- D. Phosphorus.

**Question 5.** Which hydrocarbon is 84.2% carbon by mass?

- A.  $\text{C}_8\text{H}_{18}$ .
- B.  $\text{CH}_4$ .
- C.  $\text{C}_2\text{H}_6$ .
- D.  $\text{C}_4\text{H}_{10}$ .

**Question 6.** The oxidation number of carbon in a compound cannot be

- A. +2.
- B. -4.
- C. +6.
- D. +4.

**Question 7.** A gas phase atom with an atomic number of 26 loses three electrons. What is the electron configuration of the resulting gas phase ion?

- A.  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$ .
- B.  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3 4s^2$ .
- C.  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^4 4s^1$ .
- D.  $1s^2 2s^2 2p^6 3s^2 3p^5 3d^5 4s^1$ .

**Question 8.** How many  $\sigma$  and  $\pi$  bonds are in 1,3-butadiene,  $\text{H}_2\text{C}=\text{CH}-\text{CH}=\text{CH}_2$ ?

- A. 2  $\sigma$  and 7  $\pi$  bonds.
- B. 7  $\sigma$  and 2  $\pi$  bonds.
- C. 9  $\sigma$  and 2  $\pi$  bonds.
- D. 2  $\sigma$  and 9  $\pi$  bonds.

**Question 9.** Which combination of atoms can form a non-polar covalent bond?

- A. H and Cl.
- B. N and Mg.
- C. Na and Br.
- D. O and O.

**Question 10.** What is the relationship between the two compounds below?

$\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$  and  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_3$

- A. Identical compounds.
- B. Geometric isomers.
- C. Structural constitutional isomers.
- D. Stereoisomers.

**Question 11.** Choose the most correct definition.

- A. Organic compounds are based on carbon, and they usually contain carbon-nitrogen and carbon-silicon bonds.
- B. Organic compounds are based on hydrogen, and they usually contain carbon-hydrogen and carbon-oxygen bonds.
- C. Organic compounds are based on nitrogen, and they usually contain carbon-nitrogen and carbon-hydrogen bonds.
- D. Organic compounds are based on carbon, and they usually contain carbon-hydrogen and carbon-carbon bonds.

**Question 12.** The phase transition from solid to gas without passing through the liquid state is called

- A. sublimation.
- B. melting.
- C. boiling.
- D. condensation.

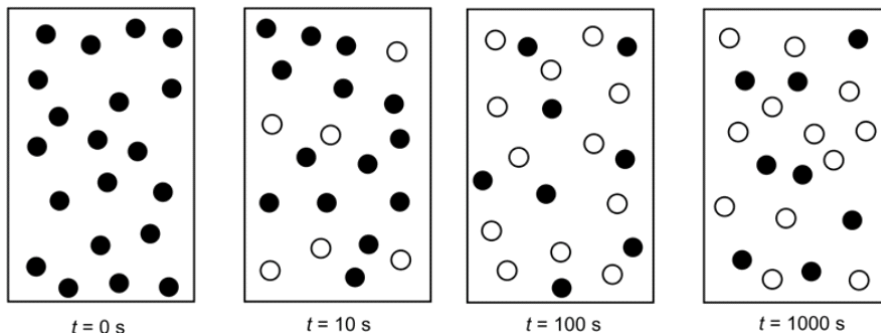
**Question 13.** When a solution of barium hydroxide is mixed with a solution of copper (II) nitrate, what is observed?

- A. Precipitation of a colored solid.
- B. Precipitation of a colorless solid.
- C. Neither precipitation nor gas evolution.
- D. Evolution of a colorless gas.

**Question 14.** What is the mass number of an atom which contains 14 protons, 14 electrons, and 15 neutrons?

- A. 14.
- B. 43.
- C. 28.
- D. 29.

**Question 15.** The diagrams below represent the progress of a reaction of  $\text{A} \rightarrow \text{B}$ , with molecules of A represented by solid circles and molecules of B represented by open circles. Which statement best describes the reaction at  $t = 1000\text{s}$ ?



- A. The reaction is not at equilibrium because the positions of the molecules are still changing.  
 B. The reaction is at equilibrium because the concentrations of A and B are no longer changing.  
 C. The reaction is not at equilibrium because the concentrations of A and B are not equal.  
 D. The reaction is not at equilibrium because not all of A has been consumed.

**Question 16.** A pH greater than 7 indicates

- A. acidity. B. alkalinity. C. purity of the sample. D. presence of ions.

**Question 17.** Which set of properties best describes a small alkane, such as ethane?

- A. polar, high boiling point, insoluble in water, extremely reactive.  
 B. non-polar, low boiling point, insoluble in water, not very reactive.  
 C. polar, low boiling point, soluble in water, not very reactive.  
 D. non-polar, high boiling point, insoluble in water, extremely reactive.

**Question 18.** Which of the following is a chemical change?

- A. Rusting of iron. B. Boiling of water.  
 C. Freezing of water. D. Dissolution of table salt in water.

**Question 19.** Which of the following solutions ( $C = 0.1 \text{ mol/L}$ ) has the highest pH value?

- A. potassium hydroxide. B. acetic acid. C. hydrochloric acid. D. ammonia.

**Question 20.** A white ionic solid is dissolved in water. Addition of a solution of sodium chloride to this solution results in a white precipitate. What was the cation in the original ionic solid?

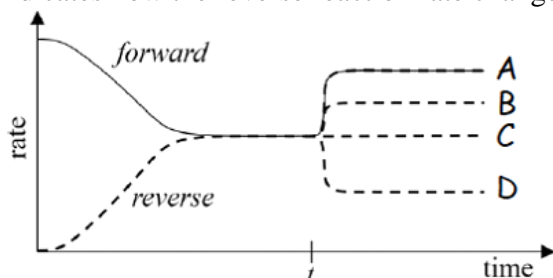
- A.  $\text{Na}^+$ . B.  $\text{Ca}^{2+}$ . C.  $\text{Fe}^{3+}$ . D.  $\text{Ag}^+$ .

**Question 21.** Which one of the following sets of ions can coexist at large in an aqueous solution?

- A.  $\text{NH}_4^+$ ,  $\text{HCO}_3^-$ ,  $\text{OH}^-$ . B.  $\text{Ba}^{2+}$ ,  $\text{Cu}^{2+}$ ,  $\text{SO}_4^{2-}$ . C.  $\text{Na}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{NO}_3^-$ . D.  $\text{Ag}^+$ ,  $\text{H}^+$ ,  $\text{Cl}^-$ .

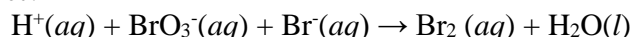
**Question 22.** A test tube contains a clear, colourless salt solution. A few drops of silver nitrate solution are added to the solution and a pale yellow precipitate forms. Which one of the following salts was dissolved in the original solution? A. NaCl. B.  $\text{K}_2\text{SO}_4$ . C.  $\text{Na}_2\text{CO}_3$ . D. KI.

**Question 23.** The graph below shows the forward and reverse rates for a reaction as a function of time. At time  $t$ , a catalyst is added to the system, and the forward reaction rate is observed to change as indicated by the solid curve. Which dashed curve best indicates how the reverse reaction rate changes?



- A. D. B. A. C. C. D. B.

**Question 24.** Bromate ion and bromide ion react to form bromine in acidic solution. When the reaction is balanced, which statement about  $\text{H}^+ (aq)$  is correct?



- A. Its coefficient is twice the coefficient of  $\text{Br}^-(aq)$ .  
 B. Its coefficient is the sum of the coefficients of  $\text{BrO}_3^-(aq)$  and  $\text{H}_2\text{O}(l)$ .  
 C. Its coefficient is twice the coefficient of  $\text{BrO}_3^-(aq)$ .  
 D. Its coefficient is twice the coefficient of  $\text{Br}_2(aq)$ .

**Question 25.** Which is the best way to prepare 500 mL of a 2.00 M solution of aqueous  $\text{H}_2\text{SO}_4$  from deionized water (density =  $1.00 \text{ g/mL}^{-1}$ ) and concentrated  $\text{H}_2\text{SO}_4$  (density =  $1.84 \text{ g/mL}^{-1}$ )?

A. Weigh 98.1 g concentrated sulfuric acid into a 500-mL volumetric flask, slowly add deionized water to the mark, and mix.

**B.** Weigh 98.1 g concentrated sulfuric acid into a 100-mL beaker, then slowly pour the  $\text{H}_2\text{SO}_4$  into a 500-mL beaker with about 250 mL deionized water in it. Pour this solution into a 500-mL volumetric flask and fill to the mark with deionized water and mix.

**C.** Weigh 98.1 g concentrated sulfuric acid into a 500-mL beaker, then slowly add deionized water to the beaker, with occasional swirling, until the liquid reaches the 500 mL mark.

**D.** Weigh 446.6 g deionized water into a 500-mL volumetric flask, fill to the mark with concentrated sulfuric acid, and mix.

**Question 26.** A 5.0 g sample of calcium nitrate ( $\text{Ca}(\text{NO}_3)_2$ ) contaminated with silica ( $\text{SiO}_2$ ) is found to contain 1.0 g calcium. What is the mass percent purity of calcium nitrate in the sample?

- A. 73%.                      B. 20%.                      C. 82%.                      D. 24%.

**Question 27.** A sample of lemon juice has a pH of 2. A sample of an ammonia cleaner has a pH of 11. If the two samples are combined, what ratio by volume of lemon juice to ammonia cleaner is needed to yield a neutral solution?

- A. 1 : 1000.                      B. 1 : 10.                      C. 10 : 1.                      D. 1 : 100.

**Question 28.** A 2.5 L sample of butane gas ( $\text{C}_4\text{H}_{10}$ ), measured at  $22.0^\circ\text{C}$  and 1.20 atm pressure, is combusted completely and the carbon dioxide gas collected at the same pressure and temperature. What volume of  $\text{CO}_2$  is produced?

- A. 2.5 L.                      B. 10.0 L.                      C. 9.0 L.                      D. 22.5 L.

**Question 29.** A 10.00 g sample of a compound containing only carbon, hydrogen and oxygen forms 23.98 g  $\text{CO}_2$  and 4.91 g  $\text{H}_2\text{O}$  upon complete combustion. What is the empirical formula of the compound?

- A.  $\text{C}_6\text{H}_6\text{O}$ .                      B.  $\text{C}_2\text{HO}$ .                      C.  $\text{C}_3\text{H}_3\text{O}$ .                      D.  $\text{C}_6\text{H}_3\text{O}_2$ .

**Question 30.**  $\text{C}(\text{s}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + \text{H}_2(\text{g}) \quad \Delta H > 0$

For the system above at equilibrium, which changes will increase the amount of  $\text{H}_2(\text{g})$ ?

- I. Adding  $\text{C}(\text{s})$   
II. Increasing the volume of the container  
III. Increasing the temperature

- A. I only.                      B. III only.                      C. I, II and III.                      D. II and III only.

**Question 31.** A 12.2 g sample containing rock salt ( $\text{NaCl}$ ) and sylvinit ( $\text{KCl} \cdot \text{NaCl}$ ) was dissolved in 100 mL of water. After the insoluble impurities were removed by filtering, the solution had a volume of 104 mL. A 10.0 mL aliquot of this solution was added to an excess of acidified aqueous silver nitrate. The resulting precipitate was filtered, dried, and weighed. Its mass was found to be 2.53 g. Another 5.00 mL aliquot of the solution was evaporated to dryness to yield 0.543 g of a solid residue. The mass percentage of  $\text{KCl} \cdot \text{NaCl}$  in the sample is

- A. 38.2%.                      B. 38.0%.                      C. 62.0%.                      D. 45.4%.

**Question 32.** A student wishes to prepare a solution with a final concentration of  $\text{Na}^+ = 0.50 \text{ M}$  and a final concentration of  $\text{HCO}_3^- = 0.10 \text{ M}$  by taking some  $\text{NaOH}$  and some trona ( $\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$ ) and diluting with water to a final volume of 1.00 L. How much  $\text{NaOH}$  and trona are required?

- A. A solution cannot be prepared with the desired concentration of  $\text{Na}^+$  and  $\text{HCO}_3^-$  using only  $\text{NaOH}$  and trona.  
B. 0.35 mol  $\text{NaOH}$ , 0.05 mol trona.  
C. 0.20 mol  $\text{NaOH}$ , 0.10 mol trona.  
D. 0.05 mol  $\text{NaOH}$ , 0.15 mol trona.

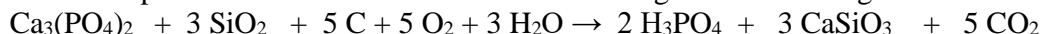
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- A. 2.95.                      B. 2.54.                      C. 3.09.                      D. 2.70.

**Question 34.** You know that salty water is particularly healthy and you want to raise the mass content of chloride in the pool water to 1%. 1 kg of pure salt costs 3500 VND. The pool has a base area of 5m x 6m and is filled up to 1.8m. The density of the water delivered by the company amounts to  $1 \text{ g/cm}^3$ . Assume an original mass content of 25 mg of chloride/100 mL of water. The expense to reach the wanted mass concentration by adding pure salt is

- A. 1.86 million VND.                      B. 2.36 million VND.                      C. 3.09 million VND.                      D. 2.41 million VND.

**Question 35.** Phosphoric acid can be manufactured according to the following reaction:



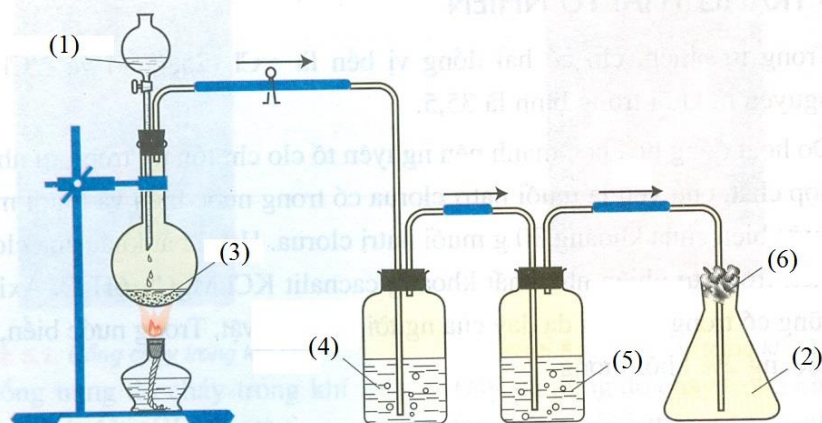
If equal masses of calcium phosphate and silica are reacted with excess carbon, oxygen and water to produce  $1.00 \times 10^3$  kg phosphoric acid, what mass of calcium phosphate was used, assuming 100% yield?

- A. 3163.3 kg.                      B. 1581.6 kg.                      C. 1583.2 kg.                      D. 1054.4 kg.

## PART II (3.0 points)

Write the solutions to the following questions in the provided space on your answer sheet.

**Question 1.** The following picture shows the experiment to prepare  $\text{Cl}_2$  in the lab.



1. Write a balanced equation to prepare  $\text{Cl}_2$  in the lab.
2. What are the names of the chemicals used in position (1), (2), (3), (4), (5), (6)?

### Question 2.

1. A 1.92 L sample (at STP) of a gaseous mixture of hydrocarbons that is 12.6% elemental hydrogen (by mass) was burnt in an excess of oxygen. The volatile combustion products were dried and bubbled through 400 mL of a 4.82% (by mass) NaOH solution with a density of  $1.05 \text{ g/cm}^3$ .

- a. Calculate the initial mass of the hydrocarbon mixture given that its specific gravity relative to nitrogen is 2.27.
- b. What volume is occupied by the resulting carbon dioxide at N.T.P
- c. Determine the qualitative composition and mass percentage of substances in the solution obtained by bubbling the carbon dioxide gas through the NaOH solution.

2. Explain and describe what happens when the excess of carbon dioxide gas is slowly bubbled through limewater.

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1. A beaker with 12.00 g of  $\text{CuSO}_4$  was set aside on vacation. One week later, precisely  $\frac{1}{3}$  of the salt transformed into pentahydrate ( $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ ). 90.00  $\text{cm}^3$  of water was casually sloshed into the beaker during cleanup after vacation. After that all the charge was transferred into a flask filled with 300.0  $\text{cm}^3$  0.0400 M NaOH solution. A formed precipitate was separated and heated until a black substance was formed and its mass remained stable. Assuming the density of water is  $1 \text{ g/cm}^3$ .

- a. Calculate the percentage of  $\text{CuSO}_4$  in the formed solution after adding water.
- b. Write all the reactions taking place and name the compounds that contain copper. Calculate the mass of the substance after heating.

2. A sample of gaseous hydrocarbon occupying 5.377 litres at N.T.P completely burnt in air produced 19.712 grams of  $\text{CO}_2$  and 8.064 grams of  $\text{H}_2\text{O}$ . Find the molecular formula and draw the electron formula of the hydrocarbon.

Note: N.T.P - Normal Temperature and Pressure - is defined as gas at  $20^\circ\text{C}$  and 1 atm.

S.T.P – Standard Temperature and Pressure - is defined as gas at  $0^\circ\text{C}$  and 1 atm.

**-THE END-**

Student's full name: .....

Student's ID: .....

First observer's name and signature: .....

Second observer's name and signature: .....

**PART I (7.0 points)**

Write the correct answer (A, B, C or D) for each of the following questions in the correspondingly numbered space on your answer sheet.

**Question 1.** The oxidation number of carbon in a compound cannot be

- A. -4.                      B. +4.                      C. +6.                      D. +2.

**Question 2.** An alkane contains 14 hydrogen atoms. How many carbon atoms does it contain?

- A. 5.                      B. 8.                      C. 6.                      D. 30.

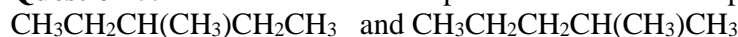
**Question 3.** A white ionic solid is dissolved in water. Addition of a solution of sodium chloride to this solution results in a white precipitate. What was the cation in the original ionic solid?

- A.  $\text{Ca}^{2+}$ .                      B.  $\text{Fe}^{3+}$ .                      C.  $\text{Na}^{+}$ .                      D.  $\text{Ag}^{+}$ .

**Question 4.** Which hydrocarbon is 84.2% carbon by mass?

- A.  $\text{C}_8\text{H}_{18}$ .                      B.  $\text{C}_4\text{H}_{10}$ .                      C.  $\text{C}_2\text{H}_6$ .                      D.  $\text{CH}_4$ .

**Question 5.** What is the relationship between the two compounds below?



- A. Geometric isomers.                      B. Structural constitutional isomers.  
C. Identical compounds.                      D. Stereoisomers.

**Question 6.** Which of the following is true?

- A. Reduction is the loss of electrons and the decrease in oxidation number.  
B. Reduction is the loss of electrons and the increase in oxidation number.  
C. Reduction is the gain of electrons and the decrease in oxidation number.  
D. Reduction is the gain of electrons and the increase in oxidation number.

**Question 7.** Which combination of atoms can form a non-polar covalent bond?

- A. Na and Br.                      B. N and Mg.                      C. H and Cl.                      D. O and O.

**Question 8.** A pH greater than 7 indicates

- A. purity of the sample.                      B. presence of ions.                      C. acidity.                      D. alkalinity.

**Question 9.** How many hydroxide ions are in 2.5 mol  $\text{Mg}(\text{OH})_2$ ?

- A.  $6.0 \times 10^{23}$ .                      B.  $3.0 \times 10^{23}$ .                      C.  $3.0 \times 10^{24}$ .                      D.  $1.5 \times 10^{24}$ .

**Question 10.** Which element does NOT have multiple allotropes?

- A. Fluorine.                      B. Oxygen.                      C. Carbon.                      D. Phosphorus.

**Question 11.** Which of the following solutions ( $\text{C} = 0.1 \text{ mol/L}$ ) has the highest pH value?

- A. ammonia.                      B. potassium hydroxide.                      C. acetic acid.                      D. hydrochloric acid.

**Question 12.** Choose the most correct definition.

- A. Organic compounds are based on hydrogen, and they usually contain carbon- hydrogen and carbon-oxygen bonds.  
B. Organic compounds are based on nitrogen, and they usually contain carbon-nitrogen and carbon-hydrogen bonds.  
C. Organic compounds are based on carbon, and they usually contain carbon-nitrogen and carbon-silicon bonds.  
D. Organic compounds are based on carbon, and they usually contain carbon- hydrogen and carbon-carbon bonds.

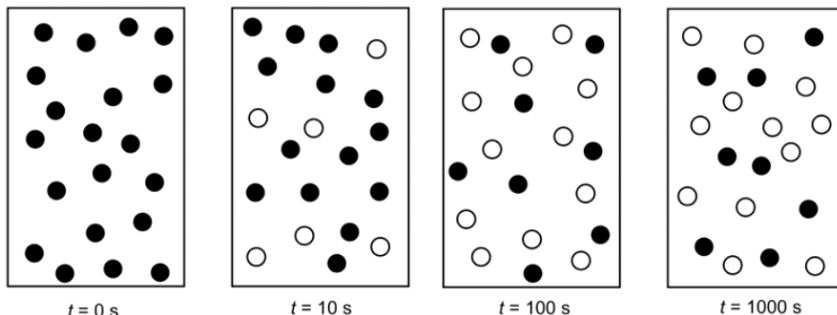
**Question 13.** Which set of properties best describes a small alkane, such as ethane?

- A. non-polar, high boiling point, insoluble in water, extremely reactive.  
B. polar, low boiling point, soluble in water, not very reactive.  
C. polar, high boiling point, insoluble in water, extremely reactive.  
D. non-polar, low boiling point, insoluble in water, not very reactive.

**Question 14.** When a solution of barium hydroxide is mixed with a solution of copper (II) nitrate, what is observed?

- A. Neither precipitation nor gas evolution.                      B. Precipitation of a colored solid.  
C. Evolution of a colorless gas.                      D. Precipitation of a colorless solid.

**Question 15.** The diagrams below represent the progress of a reaction of  $\text{A} \rightarrow \text{B}$ , with molecules of A represented by solid circles and molecules of B represented by open circles. Which statement best describes the reaction at  $t = 1000\text{s}$ ?



- A. The reaction is not at equilibrium because the positions of the molecules are still changing.  
 B. The reaction is not at equilibrium because not all of A has been consumed.  
 C. The reaction is at equilibrium because the concentrations of A and B are no longer changing.  
 D. The reaction is not at equilibrium because the concentrations of A and B are not equal.

**Question 16.** The phase transition from solid to gas without passing through the liquid state is called

- A. boiling. B. condensation. C. sublimation. D. melting.

**Question 17.** Which of the following is a chemical change?

- A. Rusting of iron. B. Freezing of water.  
 C. Dissolution of table salt in water. D. Boiling of water.

**Question 18.** How many  $\sigma$  and  $\pi$  bonds are in 1,3-butadiene,  $\text{H}_2\text{C}=\text{CH}-\text{CH}=\text{CH}_2$ ?

- A. 2  $\sigma$  and 7  $\pi$  bonds. B. 2  $\sigma$  and 9  $\pi$  bonds. C. 9  $\sigma$  and 2  $\pi$  bonds. D. 7  $\sigma$  and 2  $\pi$  bonds.

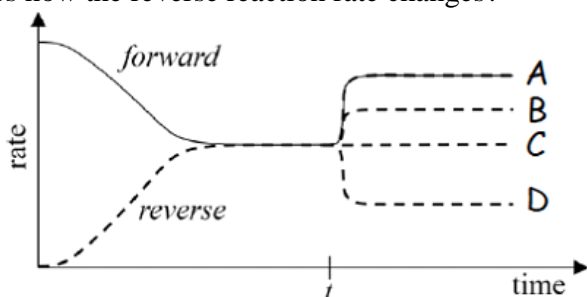
**Question 19.** A gas phase atom with an atomic number of 26 loses three electrons. What is the electron configuration of the resulting gas phase ion?

- A.  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$ . B.  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^4 4s^1$ . C.  $1s^2 2s^2 2p^6 3s^2 3p^5 3d^5 4s^1$ . D.  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3 4s^2$ .

**Question 20.** What is the mass number of an atom which contains 14 protons, 14 electrons, and 15 neutrons?

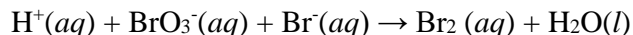
- A. 14. B. 29. C. 43. D. 28.

**Question 21.** The graph below shows the forward and reverse rates for a reaction as a function of time. At time  $t$ , a catalyst is added to the system, and the forward reaction rate is observed to change as indicated by the solid curve. Which dashed curve best indicates how the reverse reaction rate changes?



- A. A. B. C. C. D. D. B.

**Question 22.** Bromate ion and bromide ion react to form bromine in acidic solution. When the reaction is balanced, which statement about  $\text{H}^+$  (aq) is correct?



- A. Its coefficient is twice the coefficient of  $\text{Br}_2(\text{aq})$ .  
 B. Its coefficient is the sum of the coefficients of  $\text{BrO}_3^-(\text{aq})$  and  $\text{H}_2\text{O}(\text{l})$ .  
 C. Its coefficient is twice the coefficient of  $\text{BrO}_3^-(\text{aq})$ .  
 D. Its coefficient is twice the coefficient of  $\text{Br}^-(\text{aq})$ .

**Question 23.** Which is the best way to prepare 500 mL of a 2.00 M solution of aqueous  $\text{H}_2\text{SO}_4$  from deionized water (density =  $1.00 \text{ g}\cdot\text{mL}^{-1}$ ) and concentrated  $\text{H}_2\text{SO}_4$  (density =  $1.84 \text{ g}\cdot\text{mL}^{-1}$ )?

- A. Weigh 446.6 g deionized water into a 500-mL volumetric flask, fill to the mark with concentrated sulfuric acid, and mix.  
 B. Weigh 98.1 g concentrated sulfuric acid into a 500-mL volumetric flask, slowly add deionized water to the mark, and mix.  
 C. Weigh 98.1 g concentrated sulfuric acid into a 500-mL beaker, then slowly add deionized water to the beaker, with occasional swirling, until the liquid reaches the 500 mL mark.  
 D. Weigh 98.1 g concentrated sulfuric acid into a 100-mL beaker, then slowly pour the  $\text{H}_2\text{SO}_4$  into a 500-mL beaker with about 250 mL deionized water in it. Pour this solution into a 500-mL volumetric flask and fill to the mark with deionized water and mix.

**Question 24.** Which one of the following sets of ions can coexist at large in an aqueous solution?



A.  $\text{NH}_4^+$ ,  $\text{HCO}_3^-$ ,  $\text{OH}^-$ .      B.  $\text{Ba}^{2+}$ ,  $\text{Cu}^{2+}$ ,  $\text{SO}_4^{2-}$ .      C.  $\text{Na}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{NO}_3^-$ .      D.  $\text{Ag}^+$ ,  $\text{H}^+$ ,  $\text{Cl}^-$ .

**Question 25.** A test tube contains a clear, colourless salt solution. A few drops of silver nitrate solution are added to the solution and a pale yellow precipitate forms. Which one of the following salts was dissolved in the original solution?

A.  $\text{K}_2\text{SO}_4$ .      B.  $\text{KI}$ .      C.  $\text{Na}_2\text{CO}_3$ .      D.  $\text{NaCl}$ .

**Question 26.** A 2.5 L sample of butane gas ( $\text{C}_4\text{H}_{10}$ ), measured at  $22.0^\circ\text{C}$  and 1.20 atm pressure, is combusted completely and the carbon dioxide gas collected at the same pressure and temperature. What volume of  $\text{CO}_2$  is produced?

A. 22.5 L.      B. 2.5 L.      C. 9.0 L.      D. 10.0 L.

**Question 27.** A 5.0 g sample of calcium nitrate ( $\text{Ca}(\text{NO}_3)_2$ ) contaminated with silica ( $\text{SiO}_2$ ) is found to contain 1.0 g calcium. What is the mass percent purity of calcium nitrate in the sample?

A. 82%.      B. 24%.      C. 73%.      D. 20%.

**Question 28.** A sample of lemon juice has a pH of 2. A sample of an ammonia cleaner has a pH of 11. If the two samples are combined, what ratio by volume of lemon juice to ammonia cleaner is needed to yield a neutral solution?

A. 1 : 100.      B. 1 : 1000.      C. 10 : 1.      D. 1 : 10.

**Question 29.**  $\text{C(s)} + \text{H}_2\text{O(g)} \rightleftharpoons \text{CO(g)} + \text{H}_2\text{(g)} \quad \Delta H > 0$

For the system above at equilibrium, which changes will increase the amount of  $\text{H}_2\text{(g)}$ ?

- I. Adding  $\text{C(s)}$
- II. Increasing the volume of the container
- III. Increasing the temperature

A. I only.      B. II and III only.      C. I, II and III.      D. III only.

**Question 30.** A 10.00 g sample of a compound containing only carbon, hydrogen and oxygen forms 23.98 g  $\text{CO}_2$  and 4.91 g  $\text{H}_2\text{O}$  upon complete combustion. What is the empirical formula of the compound?

A.  $\text{C}_6\text{H}_3\text{O}_2$ .      B.  $\text{C}_2\text{HO}$ .      C.  $\text{C}_6\text{H}_6\text{O}$ .      D.  $\text{C}_3\text{H}_3\text{O}$ .

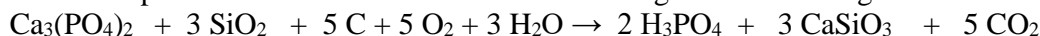
**Question 31.** Desiccated anhydrous calcium chloride was stored in an improperly closed vessel. Thus it was partially hydrated again. A 150 g sample of this material was completely dissolved in 80 g of hot water, then the solution was cooled down to  $20^\circ\text{C}$ . On cooling, 40.9 g of  $\text{CaCl}_2 \cdot 6\text{H}_2\text{O}$  precipitated. Solubility of calcium chloride at  $20^\circ\text{C}$  is 74.5 g of  $\text{CaCl}_2/100$  g of water. Determine the water content of calcium chloride in the 150 g sample (moles of water per 1 mole of  $\text{CaCl}_2$ ).

A. 2.70.      B. 2.95.      C. 2.54.      D. 3.09.

**Question 32.** A 12.2 g sample containing rock salt ( $\text{NaCl}$ ) and sylvinit ( $\text{KCl} \cdot \text{NaCl}$ ) was dissolved in 100 mL of water. After the insoluble impurities were removed by filtering, the solution had a volume of 104 mL. A 10.0 mL aliquot of this solution was added to an excess of acidified aqueous silver nitrate. The resulting precipitate was filtered, dried, and weighed. Its mass was found to be 2.53 g. Another 5.00 mL aliquot of the solution was evaporated to dryness to yield 0.543 g of a solid residue. The mass percentage of  $\text{KCl} \cdot \text{NaCl}$  in the sample is

A. 62.0%.      B. 38.0%.      C. 38.2%.      D. 45.4%.

**Question 33.** Phosphoric acid can be manufactured according to the following reaction:



If equal masses of calcium phosphate and silica are reacted with excess carbon, oxygen and water to produce  $1.00 \times 10^3$  kg phosphoric acid, what mass of calcium phosphate was used, assuming 100% yield?

A. 3163.3 kg.      B. 1583.2 kg.      C. 1581.6 kg.      D. 1054.4 kg.

**Question 34.** You know that salty water is particularly healthy and you want to raise the mass content of chloride in the pool water to 1%. 1 kg of pure salt costs 3500 VND. The pool has a base area of 5m x 6m and is filled up to 1.8m. The density of the water delivered by the company amounts to 1 g/cm<sup>3</sup>. Assume an original mass content of 25 mg of chloride/100 mL of water. The expense to reach the wanted mass concentration by adding pure salt is

A. 3.09 million VND.      B. 1.86 million VND.      C. 2.41 million VND.      D. 2.36 million VND.

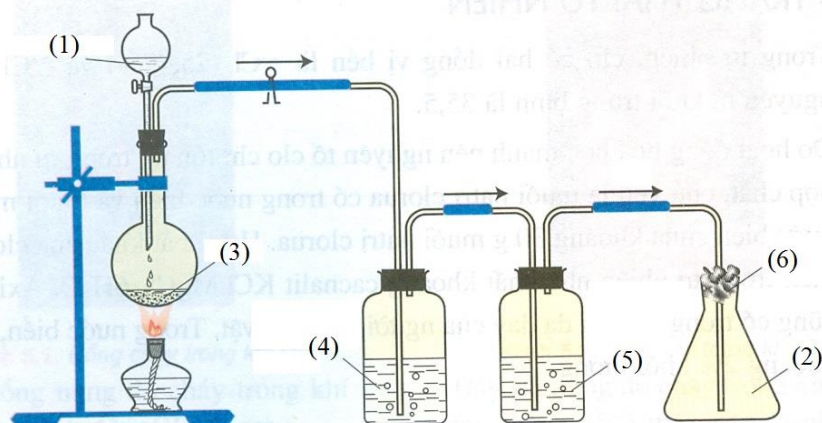
**Question 35.** A student wishes to prepare a solution with a final concentration of  $\text{Na}^+ = 0.50 \text{ M}$  and a final concentration of  $\text{HCO}_3^- = 0.10 \text{ M}$  by taking some  $\text{NaOH}$  and some trona ( $\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$ ) and diluting with water to a final volume of 1.00 L. How much  $\text{NaOH}$  and trona are required?

- A. A solution cannot be prepared with the desired concentration of  $\text{Na}^+$  and  $\text{HCO}_3^-$  using only  $\text{NaOH}$  and trona.
- B. 0.20 mol  $\text{NaOH}$ , 0.10 mol trona.
- C. 0.05 mol  $\text{NaOH}$ , 0.15 mol trona.
- D. 0.35 mol  $\text{NaOH}$ , 0.05 mol trona.

## PART II (3.0 points)

Write the solutions to the following questions in the provided space on your answer sheet.

**Question 1.** The following picture shows the experiment to prepare  $\text{Cl}_2$  in the lab.



1. Write a balanced equation to prepare  $\text{Cl}_2$  in the lab.
2. What are the names of the chemicals used in position (1), (2), (3), (4), (5), (6)?

### Question 2.

1. A 1.92 L sample (at STP) of a gaseous mixture of hydrocarbons that is 12.6% elemental hydrogen (by mass) was burnt in an excess of oxygen. The volatile combustion products were dried and bubbled through 400 mL of a 4.82% (by mass) NaOH solution with a density of  $1.05 \text{ g/cm}^3$ .

- a. Calculate the initial mass of the hydrocarbon mixture given that its specific gravity relative to nitrogen is 2.27.
- b. What volume is occupied by the resulting carbon dioxide at N.T.P
- c. Determine the qualitative composition and mass percentage of substances in the solution obtained by bubbling the carbon dioxide gas through the NaOH solution.

2. Explain and describe what happens when the excess of carbon dioxide gas is slowly bubbled through limewater.

### Question 3.

1. A beaker with 12.00 g of  $\text{CuSO}_4$  was set aside on vacation. One week later, precisely  $\frac{1}{3}$  of the salt transformed into pentahydrate ( $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ ). 90.00  $\text{cm}^3$  of water was casually slooshed into the beaker during cleanup after vacation. After that all the charge was transferred into a flask filled with 300.0  $\text{cm}^3$  0.0400 M NaOH solution. A formed precipitate was separated and heated until a black substance was formed and its mass remained stable. Assuming the density of water is  $1 \text{ g/cm}^3$ .

- a. Calculate the percentage of  $\text{CuSO}_4$  in the formed solution after adding water.
- b. Write all the reactions taking place and name the compounds that contain copper. Calculate the mass of the substance after heating.

2. A sample of gaseous hydrocarbon occupying 5.377 litres at N.T.P completely burnt in air produced 19.712 grams of  $\text{CO}_2$  and 8.064 grams of  $\text{H}_2\text{O}$ . Find the molecular formula and draw the electron formula of the hydrocarbon.

*Note: N.T.P - Normal Temperature and Pressure - is defined as gas at  $20^\circ\text{C}$  and 1 atm.*

*S.T.P – Standard Temperature and Pressure - is defined as gas at  $0^\circ\text{C}$  and 1 atm.*

**-THE END-**

Student's full name: .....

Student's ID: .....

First observer's name and signature: .....

Second observer's name and signature: .....