

國立彰化師範大學 97 學年度碩士班招生考試試題

系所：科學教育研究所碩士班

組別：丙組

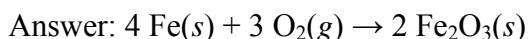
科目：普通化學

☆☆請在答案紙上作答☆☆

共 4 頁，第 1 頁

Part A : Complete and balance the overall reactions consistent with the following statements related to our everyday life. (30 points; 3 points for each equation)

Example: When iron rusts, it combines with oxygen from the air to form a reddish brown powder.



1. When an octane, a hydrocarbon that make up the mixture called gasoline, burns in sufficient oxygen.
2. The 12-volt storage battery used in automobiles is a series of six 2-volt cells. It supplies when you turn on the ignition to start the car or when the motor is off and the lights are on.
3. (Keep on the above problem) But it is recharged when the car is moving and an electric current is supplied to the battery by the mechanical action of the car.
4. Bread and many of the other foods we eat are largely made up of carbohydrates. If we represent carbohydrates with the simple example glucose, their metabolism process is constantly occurring in humans.
5. Marble building and statues, which mainly contain calcium carbonate, are disintegrated by sulfuric acid from acid rain.
6. Soap has a major disadvantage that cations from hard water precipitate soap as insoluble curds. The product is not formed in the detergent action.
7. The zeolites are perhaps the most promising of the substitutes of laundry detergent builders for sodium tripolyphosphate and sodium carbonate. The zeolite anions trap calcium ions by exchanging them for their own sodium ions.
8. When muscle contraction begins, the glycogen is converted by muscle cells in a series of steps to pyruvic acid. Pyruvic acid is an alpha-keto acid with three carbons.
9. (Keep on the above problem) Then, if sufficient oxygen and other factors are readily available, the pyruvic acid is oxidized with oxygen.
10. Nitrogen dioxide is an amber-colored gas. Smarting eyes and a brownish haze are excellent indicators of photochemical smog. It absorbs a photon of sunlight and breaks down into two species.

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Part B : Choose appropriate chemical names provided below to fill in the blanks of the descriptions regarding toothpaste. (20 points; 2 points for each blank)

ascorbic acid (vitamin C)	hydrogen peroxide	sodium carbonate
calcium fluoride	hydroxyapatite	sodium laury sulfate
carbonic acid	lactic acid	sodium percarbonate
<i>beta</i> -carotene	methyl <i>para</i> -hydroxybenzoate	sodium pyrophosphate
citric acid	phosphoric acid	sodium sulfite
diethylene glycol (DEG)	polyethylene glycol	stannous fluoride
glycerol (glycerin)	precipitated calcium carbonate	sulfur hexafluoride
hydrated aluminum	sodium bicarbonate	titanium dioxide

Toothpaste: Soap with Grit and Flavor

The only essential components of toothpaste are a detergent and an abrasive. Soap and [**sodium bicarbonate (as an example of the appropriate answer)**] can do the job quite well but would be rather unpalatable. The ideal abrasive should be hard enough to clean the teeth but not hard enough to damage the tooth enamel.

A typical detergent is [**A**]. Any pharmaceutical grade of soap or detergent probably would work satisfactorily. Most toothpastes today are full of minty flavor, colors, aroma, and sweet tastes. Ingredients include sweeteners such as sorbitol, [**B**], and saccharin; flavors such as wintergreen and peppermint; thickeners such as cellulose gum and [**C**]; and preservatives such as [**D**].

Tooth decay is caused primarily by bacterial that convert sugars to sticky detrains or plaque and to acids such as [**E**]. Acids dissolve tooth enamel. Brushing and flossing remove plaque and thus prevent decay. Decay can be minimized by eating sugars only at meals rather than in snacks, and by brushing immediately after eating. Acids such as the [**F**] in beer and pop may also erode the tooth enamel of people who consume the beverages in large amounts.

Many modern toothpastes contain fluoride compounds, such as [**G**], shown to be effective in reducing the incidence of tooth decay. The enamel of teeth is similar to [**H**] in composition. Fluoride from drinking water and from toothpaste converts a part of the enamel to fluorapatite. Fluorapatite is a stronger material than hydroxyapatite and is more resistant to decay.

A major cause of tooth loss in adults is gum disease. Toothpaste formulations that include ingredients such as [**I**] and [**J**] are purported to prevent gum disease, but there is little objective evidence that this is so.

(Source: Hill, J. W. & Kolb, D. K., *Chemistry for Changing Times*, Eighth Edition.)

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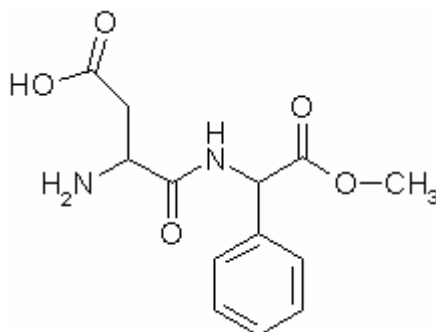
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Part C : Answer the following questions. (50 points)

1. The familiar liquid laundry bleaches are sodium hypochlorite (NaClO) solution. (a) Mixing the bleach with toilet bowl cleaners that contain hydrochloric acid is especially dangerous. Write an equation for this reaction and indicate the oxidation state for each chlorine atom. (b) Mixing the bleach with ammonia is also extremely dangerous. Give an explanation. (6 points)
2. Aspartame is an artificial sweetener marked under the name Nutra-Sweet. A simplified structure for aspartame is shown below:



- Note that partial Hs at C-H bonds are omitted. (a) How many C and N atoms exhibit sp^2 hybridization? (b) How many C and O atoms exhibit sp^3 hybridization? (c) How many σ and π bonds are in aspartame? (d) What two amino acids are used to prepare aspartame? (12 points)
3. Hemoglobin (abbreviated Hb) is a protein that is responsible for the transport of oxygen in the blood of mammals. Each hemoglobin molecule contains four iron atoms that serve as the binding sites for O_2 molecules. The oxygen binding is pH dependent. The relevant equilibrium reaction is
$$HbH_4^{4+}(aq) + 4O_2(aq) \rightleftharpoons Hb(O_2)_4(aq) + 4H^+(aq)$$
Use Le Châtelier's principle to answer the follow.

(a) What form of hemoglobin, HbH_4^{4+} or $Hb(O_2)_4$, is favored in the lungs? What form is favored in the cells? (b) When a person hyperventilates (breathe excessively hard and fast), the concentration of CO_2 in the blood decrease. How does this affect the oxygen-binding equilibrium? How does breathing into a paper bag help to counteract this effect? (c) When a person has suffered a cardiac arrest (an abrupt cessation of pump function of the heart), an injection of a sodium bicarbonate solution is given. Why is this step necessary? (10 points)
 4. Isopentyl acetate ($C_7H_{14}O_2$) is the compound responsible for the scent of bananas. Interestingly, bees release about $1 \mu g$ ($1 \times 10^{-6} g$) of this compound when they sting. The resulting scent attracts other bees to the attack. (a) Calculate the molar mass of isopentyl acetate. (b) How many molecules of isopentyl acetate are released in a typical bee sting? (c) How many atoms of carbon are present? (Molar mass: C = 12.01 g/mol, H = 1.008 g/mol, and O = 16.00 g/mol) (Show detailed problem-solving processes. The calculation results might be ignored if calculator is prohibited.) (6 points)

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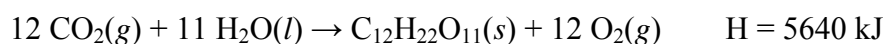
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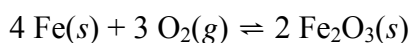
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5. The sun supplies energy at a rate of about 1.0×10^3 watt per square meter of surface area (1 watt = 1 J/s). The plants in an agricultural field produce the equivalent of 20. kg of sucrose ($C_{12}H_{22}O_{11}$) per hour per hectare (1 ha = 10,000 m²). Assume that sucrose is produced by the reaction



- (a) Calculate the energy needed for producing 20. kg of sucrose. (b) Compute the energy from sun supplied to the agricultural field per hour. (c) Calculate the percentage of light used to produce the sucrose - that is, determine the efficiency of photosynthesis. (Molar mass: sucrose = 342.30 g/mol) (Show detailed problem-solving processes. The calculation results might be ignored if calculator is prohibited.) **(8 points)**
6. The formation of rust on bare steel is a spontaneous process. The overall reaction for the corrosion (rusting) of iron by oxygen is



Using the following data and the temperature at 25 °C, for this reaction, calculate (a) the change in enthalpy, (b) the change in entropy, (c) the change in free energy, and (d) the equilibrium constant. (Show detailed problem-solving processes. The calculation results might be ignored if calculator is prohibited.) **(8 points)**

Substance	ΔH_f° (kJ/mol)	S° (J/K . mol)
$\text{Fe}_2\text{O}_3(s)$	- 826	90
$\text{Fe}(s)$	0	27
$\text{O}_2(g)$	0	205