

平成 21 年度 理学系研究科博士前期課程 入学試験問題

(分子科学専攻・冬募集)

英語

試験時間 : 10:30 ~ 12:00

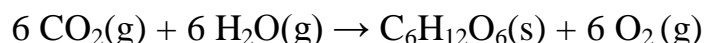
配点 : 150 点

【注意】

- (1) 問題冊子（1部）、解答用紙（3枚）を配布する。
各解答用紙には、解答すべき問題番号があらかじめ記されている。
手元に上記のすべてが所定枚数配布されていることを確認すること。
過不足がある場合には速やかに申し出ること。
- (2) すべての解答用紙に受験番号と氏名とを必ず記入すること。
- (3) 解答は、問題番号ごとにそれぞれ指定された解答用紙に記入すること。
解答用紙は裏面を使用してもよい。

1. 次の文章を読んで、設問に答えよ。

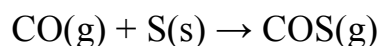
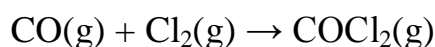
(1)Carbon forms two stable oxides, carbon monoxide and carbon dioxide. Our atmosphere contains about 0.04% carbon dioxide by volume. Plants use atmospheric carbon dioxide to produce sugars during photosynthesis.



Carbon dioxide is returned to the atmosphere by animal respiration, plant and animal decay, and (in modern history) fossil fuel combustion. (2)Because carbon dioxide is highly soluble in water, the oceans of the world act as a reservoir for CO₂, keeping the amount of CO₂ in the atmosphere generally stable. (3)However, the increase in the combustion of fossil fuels in the last century has increased the amount of CO₂ in the atmosphere by about 25%.

At atmospheric pressure, the liquid phase of CO₂ does not exist. Solid carbon dioxide sublimates directly to the gas phase when heated, which is why solid CO₂ is often called (ア).

Carbon monoxide (CO) is a colorless, odorless, and tasteless gas. The boiling point of carbon monoxide is -192 °C at atmospheric pressure, and CO is only very slightly soluble in water. (4)Carbon monoxide is toxic because it interferes with the ability of hemoglobin to bind oxygen. Unlike carbon dioxide, which is very stable, carbon monoxide is relatively reactive and can be used as a reducing agent. For example, carbon monoxide reacts with oxygen and metal oxide to form carbon dioxide. Carbon monoxide also reduces many nonmetals, producing compounds with the reduced form of the nonmetal.



The product of the first reaction listed above is phosgene (COCl₂), also known as carbonyl chloride, a poisonous gas that was used in World War I as a chemical weapon. Phosgene is now an important industrial chemical used in the production of polycarbonates. The product of the second reaction, carbonyl sulfides (COS), is a fungicide.

【注】 *respiration*: The process of taking in oxygen from inhaled air and releasing carbon dioxide by exhalation.

decay: Natural chemical change that causes the slow destruction of something.

fungicide: Chemical compounds used to prevent the spread of fungi or plants in gardens and crops.

問1 下線部 (1) ~ (4) を日本語に訳せ。

問2 問題文の (ア) に当てはまる言葉を日本語で答えよ。

問3 Carbon monoxide の物理的性質及び化学的性質を本文にそって要約せよ。

2. 次の文章を読んで設問に答えよ。

Consider the third electron in a lithium atom. It is affected by the charge on the nucleus (+3). However it is also repelled by the charge on the inner two electrons. Figure 1 shows the radial density distribution functions for the lithium 1s, 2s, and 2p orbitals. (1)It is clear that the electrons in the 1s orbital are much closer to the nucleus than any electrons in the 2s or 2p orbital. (2)The two inner electrons in the 1s orbital screen the third electron from the full effect of the nuclear +3 charge. The difference between the full nuclear charge, Z , and the screening effect of the inner two electrons is called the *effective nuclear charge*, or Z_{eff} . In general for any multi-electron atom, any particular electron will always be screened from the nucleus to some extent by the remaining electrons.

$$Z_{eff} = Z - \text{screening constant}$$

Examine the region closer to the nucleus, where r is small. There is a significant amount of electron density very close to the nucleus for the 2s orbital which is effectively inside the 1s orbital. In other words the 2s orbital intrudes inside the volume of space occupied by the 1s orbital. There is no such effect for the 2p orbital, although there is some penetration. The upshot this is that (3)the 1s electrons shield an electron in the 2s orbital less effectively than they shield an electron in a 2p orbital. (4)The effective nuclear charge Z_{eff} experienced by an electron in a 2s orbital is greater than that experienced by an electron in a 2p orbital. The energy of an electron in an orbital is dependent upon 1 and calculations show that the energy of the third lithium electron is lower if it is in the 2s orbital rather than in a 2p orbital. The preferred configuration is therefore $1s^2 2s^1$ rather than $1s^2 2p^1$.

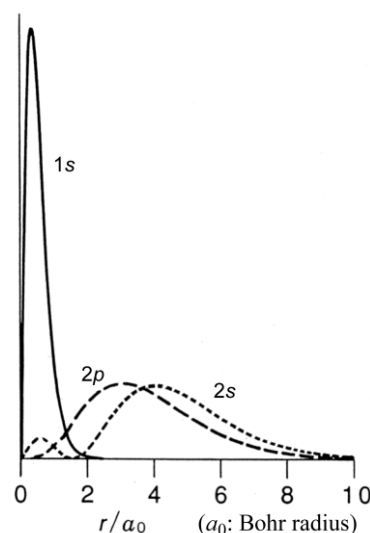


Figure 1. Radial distribution functions for lithium 1s, 2s, and 2p orbitals.

問1 下線部 (1) ~ (4) を日本語に訳せ。

問2 空欄 1 にあてはまる語句を英語で記せ。

3. 次のそれぞれの英文の内容を表す化学用語を、英語および日本語で記せ。解答の際は、5題を自由に選び、それぞれの問題番号を付して答えよ。

- (1) A liquid or gas that dissolves a solid, liquid, or gaseous solute, resulting in a solution.
- (2) A fragment of a molecule containing at least one unpaired electron.
- (3) The intrinsic rotational motion of an electron.
- (4) A substance that facilitates a reaction without itself being consumed.
- (5) The state in which the concentrations of the reactants and products have no net change over time.
- (6) A chemical property that describes the ability of an atom (or, more rarely, a functional group) to attract electrons (or electron density) towards itself in a covalent bond.
- (7) A reagent that forms a chemical bond to its reaction partner by donating both bonding electrons.
- (8) Either an atom, ion, or molecule that bonds to a central metal, generally involving formal donation of one or more of its electrons.
- (9) A method of separating chemical substances based on differences in their volatilities in a boiling liquid mixture.
- (10) The formation of a solid in a solution during a chemical reaction.
- (11) A type of atom that is distinguished by its atomic number; that is, by the number of protons in its nucleus.