※設置認可申請中

大阪公立大学（仮称）

一般選抜　個別学力検査等　サンプル問題

日程等	後期日程（理学部　化学科）
教科等	外国語
科目名等	英語
試験時間	120 分

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英　　語（化学科）

第１問　（100 点）

次の英文を読んで，問１ ～ 問５に答えよ。

For most of the nineteenth century, atoms were considered to be indivisible, stable particles, as proposed by Dalton. Toward the end of the century, however, new experiments indicated that an atom is composed of even smaller subatomic particles.

One of the first experiments on subatomic particles was carried out by the English physicist J. J. Thomson in 1897. Some years earlier, it had been discovered that an electric discharge (glowing current) flows between metallic electrodes that are sealed in a partially evacuated glass tube. These glowing discharges were called cathode rays. Scientists knew that these rays were not caused by atoms or heavier particles because the mass of the two plates in the apparatus remained constant. Much debate among physicists ensued over the nature of the rays. ①Thomson deflected the rays with electric and magnetic fields and showed that they were actually streams of identical, negatively charged particles. He correctly reasoned that these particles, which are now called electrons, are constituents of atoms. The electron was the first subatomic particle to be discovered.

Thomson's discharge tube experiment along with later experiments showed that the mass of an electron is 9.109×10^{-31} kg and that its charge is -1.602×10^{-19} C, where C is the symbol for coulomb, the SI unit of charge. It is often convenient to express charges as multiples of 1.602×10^{-19} C. Thus the charge on an electron is −1 in this convention. The mass of an electron is only 1/1800 the mass of a hydrogen atom, confirming Thomson's assumption that an electron is a subatomic particle.

②If an atom contains electrons, which are negatively charged particles, then it also must contain positively charged particles because atoms are electrically neutral. The total amount of negative charge in a neutral atom must be balanced by an equal amount of positive charge. The question is: How are the positively charged particles and electrons arranged within an atom?

In the early 1900s, the New Zealand-born physicist Ernest Rutherford discovered α-particles, which have a charge equal in magnitude to that of two electrons but of opposite (i.e., positive) sign and a mass equal to the mass of a helium atom. Rutherford became intrigued with the idea of using the newly discovered α-particles as subatomic projectiles. He directed a beam of α-particles at a gold foil and observed the paths of the α-particles by watching for flashes as they struck a fluorescent screen surrounding the foil. Because most scientists believed at the time that the positive charge in atoms was spread uniformly throughout the atom, Rutherford expected the tiny fast-moving α-particles to tear through the foil. They assumed that the trajectories of the α-particles would be altered only slightly (at most by two degrees).

Contrary to expectations, while most of the α-particles passed straight through the foil, a few "bounced back," being deflected through large angles. These results astounded Rutherford as he was to relate in a later lecture, "It was quite the most incredible event that ever happened to me in my life. It was almost as incredible as if you fired a 15-inch shell at a piece of tissue paper and it came back and hit you!" Rutherford interpreted this astonishing result to mean that all the positive charge and the bulk of the mass of an atom are concentrated in a very small volume at the center, which he called the nucleus. He named this the nuclear model of the atom. The electrons in an atom are located throughout the space surrounding the nucleus.

【出典：D. A. McQuarrie, P. A. Rock, E. B. Gallogly, *General Chemistry*, 4th ed., University Science Books (2011), 一部改変】

（注）indivisible: 分割できない, electric discharge: 放電, glowing current: 発光を伴う電流, electrode: 電極, evacuated glass tube: 真空ガラス管, cathode ray: 陰極線, apparatus: 装置, ensue: 続く, deflect: 偏向させる, radioactivity: 放射能, emit: 発する, magnitude: 大きさ, intrigue: 好奇心をそそる, subatomic projectile: 原子より小さい弾丸, gold foil: 金箔, fluorescent: 蛍光性の, tear through ~：~ を通り抜ける, trajectory: 軌跡, bounce back: 跳ね返る, astound: びっくり仰天させる, nucleus: 核

問１　下線部①の実験から導かれた学説を日本語で記せ。

問２　本文の内容から，水素原子の質量を有効数字３桁で求めよ。

問３　下線部②を日本語に訳せ。

問４　Rutherford の α 粒子を用いた実験に関して，（a）～（c）の設問に本文の内容に沿って日本語で答えよ。

(a) 実験方法を 50 字以内で説明せよ。

(b) この実験が行われる以前は，どのような学説が主流だったか答えよ。また，その学説から予測された実験結果を述べよ。

(c) 実際に観測された実験結果を述べよ。また，この実験結果から導かれた結論を記せ。

問５　本文の内容を適切に表す題名を英語で与えよ。

英　　語（化学科）

第２問　（100 点）

次の英文を読んで，問１ 〜 問７に答えよ。

Sodium, potassium and their compounds have many uses. The varied applications of compounds of Na include those in the paper, glass, detergent, chemical and metal industries. In 2008, the world production of NaCl was 258 Mt (megatons). Of this, 47.6 Mt were produced and 60.5 Mt consumed in the US. ①<u>The major consumption of NaCl is in the manufacture of NaOH, Cl_2 and Na_2CO_3</u>. A large fraction of NaCl is used for winter road de-icing. However, in addition to the corrosive effects of NaCl, environmental concerns have focused on the side-effects on roadside vegetation and run-off into water sources. Increasing awareness of these problems has led to the introduction of reduced-salt road maintenance schemes and the use of calcium magnesium acetate in place of NaCl as a road de-icing agent.

In 2008, the US used 23 Mt of NaCl for the control of ice on roads. The great advantage of NaCl is that it is cheap. The disadvantages are that it is corrosive to motor vehicles and to concrete structures such as bridges and, when the snow melts, it is carried into water courses. The environmental effects that this has on water supplies and to fish and vegetation are a cause for concern and a topic of current research. Sodium chloride acts most effectively as a de-icing agent at temperatures above –6 ºC. Calcium chloride is also commonly applied as a road de-icing agent. Its advantage over NaCl is that, when applied as solid anhydrous $CaCl_2$, it is effective at temperatures as low as –32 ºC. An added benefit of using anhydrous $CaCl_2$ is that its dissolution into melted snow or ice is an exothermic process which results in further snow or ice melting. Aqueous solutions of $CaCl_2$ (sold as 'liquid $CaCl_2$') are also applied to roads. A solution that is 32% $CaCl_2$ by weight is an effective de-icing agent down to –18 ºC. Two disadvantages of $CaCl_2$ are that it is significantly more corrosive than NaCl, and it is more expensive. One compromise is to pre-wet NaCl with $CaCl_2$ solution, and the application of 'pre-wetted salt' to roads is common practice.

②<u>While NaCl and $CaCl_2$ have been applied as winter road de-icing agents for many years, their environmental disadvantages and corrosive properties make them far from ideal</u>. The corrosive nature of chloride de-icers makes them unsuitable for de-icing aircraft, and glycols are typically used for this purpose. An alternative to NaCl and $CaCl_2$ is the double salt calcium magnesium acetate (CMA), the potential of which was first recognized in the 1970s. CMA is manufactured by treating calcined dolomite ($CaO{\cdot}MgO$) with acetic acid but, generated in this way, the product is about five times as expensive as NaCl. CMA is most efficient as a de-icer above –7 ºC and therefore compares favorably with NaCl. However, CMA has many advantages. It is far less corrosive than chloride de-icers, exhibits a low toxicity to vegetation and aquatic wildlife, and is biodegradable. Both NaCl and $CaCl_2$ are mobile in groundwater, and about 50% of NaCl applied to roads ends up in groundwater supplies. In contrast, CMA is poorly mobile in soil and shows a low tendency to reach groundwater. Current research into cheaper routes to its manufacture include oxidation of organic food waste and fermentation processes, e.g. from calcined dolomite and whey lactose. The latter is converted to lactic acid by the bacterium *Lactobacillus plantarum*, and then to acetic and propanoic acids by *Propionibacterium acidipropionici*.

About 21% of $CaCl_2$ produced in North America is consumed in road de-icing. A further 27% is used to control dust on unpaved roads. This application arises from the hygroscopic nature of $CaCl_2$. Addition of anhydrous $CaCl_2$, flaked $CaCl_2$ (78% $CaCl_2$ and 22% moisture) or 'liquid $CaCl_2$' (which dries out *in situ*) to dusty road surfaces provides a means of trapping water, thereby helping to aggregate the dust particles. In addition to reducing dust pollution, particle aggregation helps to slow down deterioration of the road surface. Canada, for example, uses $CaCl_2$ widely on its 'dirt roads', and in 2000, ≈100 kt were applied across the country.

【出典:C. E. Housecroft and A. G. Sharpe, *Inorganic Chemistry*, 4th ed., Pearson (2012), 一部改変】

（注）detergent : 洗剤，consume : 消費する， corrosive : 腐食性の，vegetation : 植物，run-off : 表面流水（地下に吸収されずに地上を流れる水），compromise : 妥協，unsuitable : 不適当な，glycols : グリコール類（エチレングリコールなど），calcine :（無機塩を）焼いて粉状にすること，generate : 発生させる，fermentation : 発酵，e.g.: 例えば， whey : 乳清，ホエー，bacterium : 細菌，unpaved : 未舗装の，hygroscopic : 吸湿性の，*in situ* : その場で，aggregate : 凝集させる，deterioration : 悪化

問１　下線部①に関して，以下の（a），（b）の設問に答えよ。

（a）NaOH および Cl_2 は，NaCl 水溶液の電気分解によって製造される。このとき陽極と陰極で起こる反応を，それぞれ e^-を含む反応式であらわせ。

（b）Na_2CO_3 は，アンモニアソーダ法により製造される。この製法により NaCl から Na_2CO_3 がつくられる過程を２つの化学反応式であらわせ。

問２　NaCl や $CaCl_2$ を融雪剤として利用することの問題点を，本文の内容に沿って日本語で述べよ。

問３　$CaCl_2$ が NaCl よりも融雪剤として優れている点を，本文の内容に沿って日本語で述べよ。

問４　下線部②を日本語に訳せ。

問５　CMA は $CaMg_2(CH_3COO)_6$ の示性式であらわされる。以下の（a），（b）の設問に答えよ。原子量は，C = 12，H = 1.0，O = 16，Mg = 24，Ca = 40 を用いよ。

（a）CMA には質量パーセントで Ca が何%含まれているか。有効数字２桁で求めよ。

（b）水 3.0 kg に 442 g の CMA が溶けた水溶液の凝固点〔ºC〕を有効数字２桁で求めよ。ただし，水のモル凝固点降下は 1.85 K・kg / mol であり，CMA は完全に電離しているものとする。

問６　CMA が $CaCl_2$ や NaCl よりも融雪剤として優れている点を，本文の内容に沿って日本語で述べよ。

問７　$CaCl_2$ の融雪剤以外の主要な用途について，本文の内容に沿って日本語で説明せよ。また，それは $CaCl_2$ のどのような性質を利用したものかを記せ。

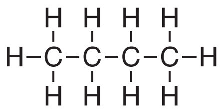
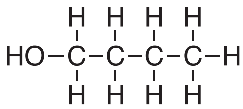
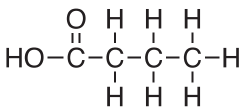
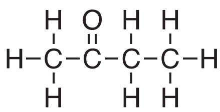
英　　語（化学科）

第３問　（100 点）

次の英文を読んで，問１ 〜 問５に答えよ。

Compare the structural formulas of the molecules shown in Table 1. Notice that each of these molecules consists of four carbon atoms joined to one another by a single bond and arranged in a linear fashion. Notice, however, that each molecule, with the exception of butane, has a different functional group attached to one of these carbon atoms. As a result, each molecule has properties that differ greatly from butane.

Table 1 Comparing classes of organic compounds

Name	Structural formula	Melting point (°C)	Boiling point (°C)	Density (g/cm^3)
Butane		−138	−1	0.58
1-Butanol		−90	117	0.81
Butanoic acid		−5	164	0.96
2-Butanone		−86	80	0.81

First of all, compare the boiling point of butane with those of the other compounds in Table 1. Butane is a gas at room temperature. Because of the symmetrical arrangement of the atoms, butane is nonpolar. Because the intermolecular forces between butane molecules are weak, butane has very low melting and boiling points and a lower density than the other three molecules.

Second, compare the structural formulas of butane and 1-butanol in Table 1. Notice that the only difference between these two molecules is the presence of the functional group –OH on one of the carbon atoms in 1-butanol. The presence of this functional group causes 1-butanol to exist as a liquid at room temperature with much higher melting and boiling points and a significantly greater density than butane by intermolecular hydrogen bonding interactions.

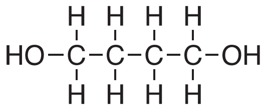
Butanoic acid has much higher melting and boiling points than butane, 1-butanol, or 2-butanone in Table 1. Those specific physical properties are caused by ①butanoic acids existing as dimers, in which two molecules of butanoic acid form two hydrogen bonds with each other.

Finally, compare the physical properties of butane, 1-butanol, and 2-butanone in Table 1. 2-Butanone is a liquid at room temperature. Because of the presence of the functional group >C=O, 2-butanone is polar and forms intermolecular dipole-dipole interactions. Therefore, 2-butanone has much higher melting and boiling points than butane. However, 2-butanone has a lower boiling point than 1-butanol because the intermolecular forces between 2-butanone molecules are weaker than those between 1-butanol molecules. On the other hand, 2-butanone and 1-butanol have similar melting points despite the difference in the strength of the intermolecular forces. ②It is known that the melting point is strongly influenced not only by the intermolecular forces but also by the shape of molecule. Especially, high molecular symmetry is associated with high melting point because of highly favorable crystal packing. 2-Butanone has a more symmetrical shape than 1-butanol. As the result, 2-butanone and 1-butanol have similar melting points.

【出典 : T. Myers, K. B. Oldham, S. Tocci, *Holt Chemistry*, Holt, Rinehart & Winston (2004), 一部改変】

（注）functional group : 官能基，property : 特性，molecules : 分子，in a linear fashion : 直鎖状に，nonpolar : 非極性の，symmetrical : 対称的な，intermolecular forces : 分子間力，butanoic acid : ブタン酸（酪酸），intermolecular dipole-dipole interactions : 分子間双極子-双極子相互作用，is associated with : ～と関係がある，multiple : 複数の

問１　1,4-ブタンジオールの沸点 (228 °C) は 1-ブタノールの沸点よりも非常に高い。その理由を本文の内容に沿って日本語で答えよ。

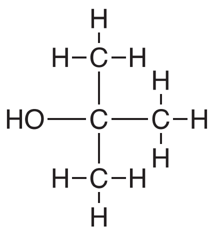


1,4-ブタンジオール

問２　下線部①の状態を構造式で示した上で，ブタン酸の密度が 1-ブタノールの密度より大きい理由を本文の内容に沿って日本語で答えよ。

問３　下線部②を日本語に訳せ。

問４　2-メチル-2-プロパノールの融点 (26 °C) は 1-ブタノールの融点よりも高い。その理由を本文の内容に沿って日本語で答えよ。



2-メチル-2-プロパノール

問５　以下の文章を英訳せよ。

同じ官能基を持つ分子は，大きさが異なっていても類似した性質を示す。一方，異なる官能基を持つ分子は，類似した大きさであっても異なった性質を示す。