

(2015)

CHEMISTRY	Nationality		No.		Marks	
	Name	(Please print full name, underlining family name)				

I Write the reference number of the correct answer to each question in the appropriate box on the Answer Sheet below.

(1) Which of the atoms and ions 1) to 4) has a different electron configuration from those of the others?

- 1) F^- 2) Ne 3) Na^+ 4) Ar

(2) Which of acid aqueous solution 1) to 4) is non-volatile one?

- 1) CH_3COOH 2) H_2SO_4 3) HCl 4) HF

(3) Which of the substances 1) to 4) contains a triple bond?

- 1) hydrochloric acid 2) sulfuric acid
 3) cyanic acid 4) formic acid

(4) Which of the substances 1) to 4) is a liquid under atmospheric pressure at 25 °C?

- 1) F_2 2) Cl_2 3) Br_2 4) I_2

(5) Which of the descriptions 1) to 4) is not correct for the properties of sodium?

- 1) The unit cell of crystalline sodium has a cubic shape.
 2) Sodium metal is chemically stable in an ambient atmosphere.
 3) The reaction with alcohol produces H_2 .
 4) Using a flame test, sodium shows as a bright yellow color.

(6) Which combination of the substances 1) to 4) will not produce ammonia under appropriate temperature and pressure conditions?

- 1) copper and concentrated nitric acid
- 2) nitrogen and hydrogen
- 3) urea and water
- 4) calcium hydroxide and ammonium chloride

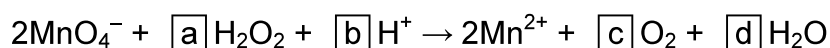
(7) Which of the descriptions 1) to 4) is appropriate for the phase diagram of pure substances?

- 1) The slope of the gas-solid boundary is negative.
- 2) The gas-liquid boundary extends infinitely towards higher temperatures and pressure.
- 3) The solid-liquid boundary of water is positive.
- 4) At the triple point, three phases coexist at a specified temperature and pressure.

(1)		(2)		(3)		(4)	
(5)		(6)		(7)			

II

(1) Under acidic conditions, manganese peroxide reacts with hydrogen peroxide as shown below.

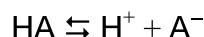


Give the appropriate values for $\boxed{\text{a}}$ to $\boxed{\text{d}}$ in this reaction.

(2) Write a chemical reaction formula where Mn^{2+} is oxidized by H_2O_2 to produce MnO_2 under basic conditions.

(1)	a		b		c		d	
(2)								

III When dissolved in water, a weak acid HA partially dissociates as shown below;



The degree of dissociation, α , is defined as the fraction of HA dissociated in water. The dissociation constant, K_a , is defined as the product $[\text{H}^+][\text{A}^-]$ divided by $[\text{HA}]$, where the brackets denote the concentrations of the respective chemical species. Give the appropriate answers to the following questions.

- (1) Setting the initial concentration of HA as C , write an expression of K_a using α and C .
- (2) Show an expression of $[\text{H}^+]$ using K_a , C and C_{salt} when HA and a corresponding sodium salt NaA is dissolved together in water with initial concentrations of $[\text{HA}] = C$ and $[\text{NaA}] = C_{\text{salt}}$.
 Provided that $x \gg y$, you can use an approximate equation: $x \pm y \approx x$.

(1)	$K_a =$	(2)	$[\text{H}^+] =$
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IV Give the names of appropriate element for (a) ~ (d) in the passages below.

(1) (a) and (b) are elements that belong to period 5 and 6 in the periodic table, respectively. Both simple substances are solid under room temperature. To an aqueous solution containing cations of (a) and (b), dilute hydrochloric acid was dropped to produce white precipitate. Upon rinsing with boiling water, the precipitate was partially dissolved.

(2) Both (c) and (d) are elements that produce stable trivalent cations in an aqueous solution. To an aqueous solution containing (c) and (d) as trivalent cations, aqueous ammonia was dropped to produce a gel-like precipitate. Upon the addition of concentrated aqueous sodium hydroxide, the precipitate was partially dissolved and the majority of (c) was transferred to the supernatant.

(a)		(b)	
(c)		(d)	

V Write the correct answer in the appropriate box on the Answer Sheet below.

- (1) How many structural isomers exist for C_5H_{12} ?
- (2) How many structural isomers have an asymmetric carbon for C_5H_{12} ?
- (3) How many classes of alcohol exist for $C_4H_{10}O$?
- (4) How many classes of ether exist for $C_4H_{10}O$?
- (5) Which of the substances 1) to 4) has the highest boiling point?

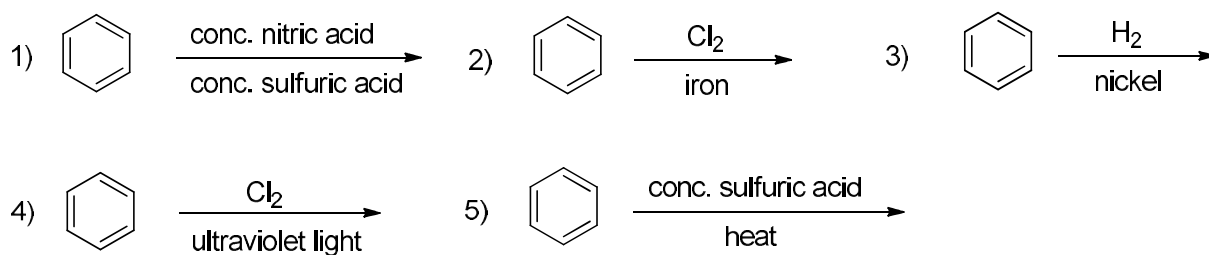
1) hexane

2) 1-pentanol

3) ethyl propyl ether

4) 3-pentanone

- (6) Which reactions 1) to 5) result in an addition reaction? Choose two.



- (7) How many structural isomers exist for dipeptides that are prepared from a mixture of alanine and glycine?
- (8) Which sugars 1) to 5) are not reducing sugars?

1) sucrose

2) maltose

3) glucose

4) lactose

5) fructose

(1)		(2)		(3)		(4)	
(5)		(6)		(7)		(8)	

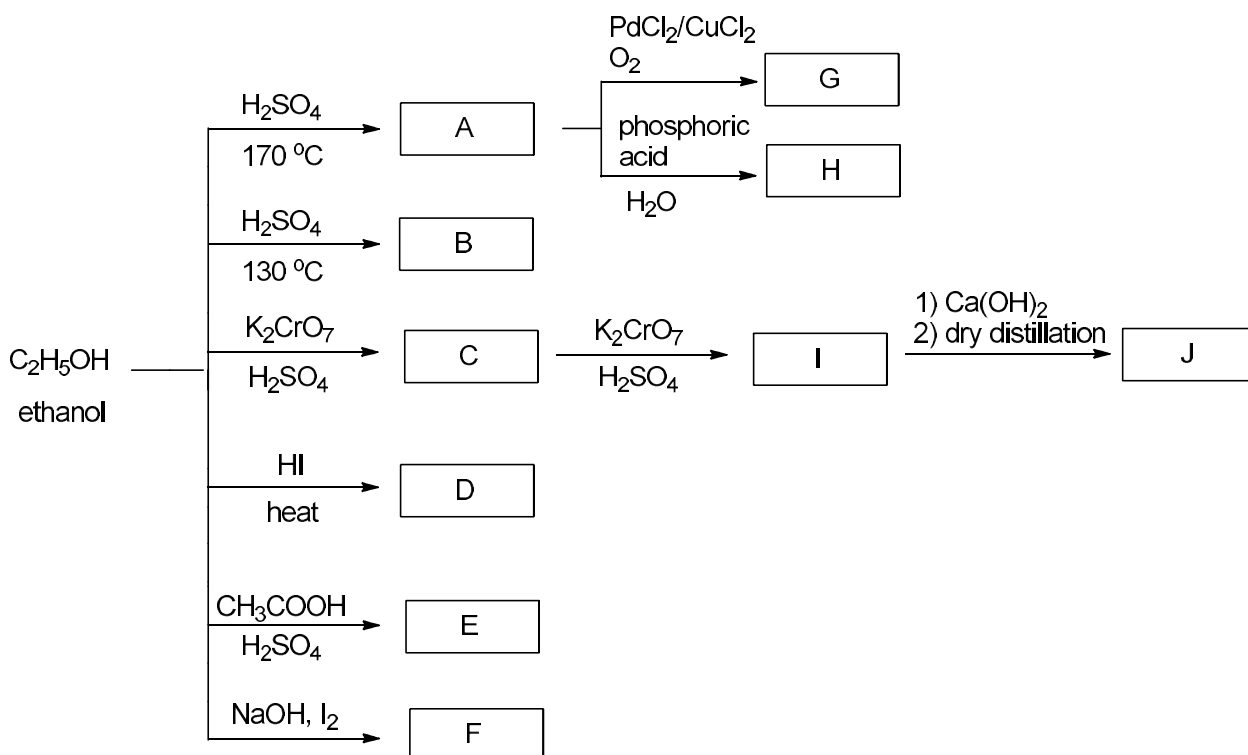
VI Answer the following questions about phenol.

- ① It is soluble in water and its aqueous solution is neutral.
- ② Its aqueous solution is acidic.
- ③ Its aqueous solution is basic.
- ④ It undergoes silver mirror reaction.
- ⑤ It undergoes color reaction with aqueous iron (III) chloride to result in a bluish purple coloration.
- ⑥ It does not react with nitric acid.
- ⑦ It easily reacts with hydrogen gas.
- ⑧ It reacts with Fehling's solution to reduce Cu^{2+} .

- (1) Which of the descriptions ①—⑧ is correct for the property of phenol? Choose two.
- (2) Phenol is industrially produced from the () process. Give the appropriate name of the industrial method.
- (3) The reaction of phenol with sodium metal generates a gas. What is the gas? Give the appropriate name of the gas.
- (4) The reaction of phenol with bromine molecule gives 2,4,6-tribromophenol. How many moles of bromine molecule are required in order to get 298g of 2,4,6-tribromophenol from 94g of phenol? The reaction is supposed to proceed theoretically. Here, atomic masses are $\text{H} = 1$, $\text{C} = 12$, $\text{O} = 16$, $\text{Br} = 80$.
- (5) Phenolic resin (Bekelite) is one of thermosetting resins. Which compound with phenol is required for the phenolic resin formation?

(1)	(2)	(3)	(4)	(5)

VII Outlined here are synthetic processes of organic compounds. Select the structural formulas for the compounds **A** to **J** from (1)-(24). You may use the same number for an answer several times.



(1) $\text{CH}_3\text{CH}_2\text{Cl}$ (2) $\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3$ (3) $\text{CH}_3\text{CH}_2\text{CN}$ (4) BrHC=CHBr (5) $\text{[CH}_2\text{-CH}_2\text{]}_n$

(6) CH_3CHO (7) CH_3COOH (8) CHI_3 (9)  -CH=CH_2 (10) $\text{H}_2\text{C=CHC(=O)CH}_3$

(11) $\text{H}_2\text{C=CH-C}\equiv\text{CH}$ (12) $\text{H}_2\text{C=CH}_2$ (13) $\text{H}_2\text{C=CHCN}$ (14) CH_3OH (15) $\text{H}_3\text{C-C(=O)-CH}_3$

(16) $\text{CH}_3\text{CH}_2\text{CH}_3$ (17)  (18) $\text{H}_2\text{C=CH-C(=CH}_2\text{)Cl}$ (19)  -CH_3 (20) $\text{H}_2\text{C=CHOC(=O)CH}_3$

(21) $\text{CH}_3\text{CH}_2\text{OH}$ (22) $\text{CH}_3\text{CH}_2\text{I}$ (23) $\text{CH}_3\text{-C(=O)-OCH}_2\text{CH}_3$ (24) $\text{HOCH}_2\text{CH}_2\text{OH}$

A	B	C	D	E
F	G	H	I	J