

**NANYANG TECHNOLOGICAL UNIVERSITY  
SINGAPORE**

**ENTRANCE EXAMINATION  
CHEMISTRY (Sample)**

Time Allowed : **2 hours**

**INSTRUCTIONS**

1. This paper consists of **TWO (2)** Sections and comprises **EIGHT (8)** pages.
  2. Answer **ALL** the questions in Section A and Section B.
  3. For Section A, each multiple choice question carries 2 marks. Section B consists of 3 questions (total 40 marks).
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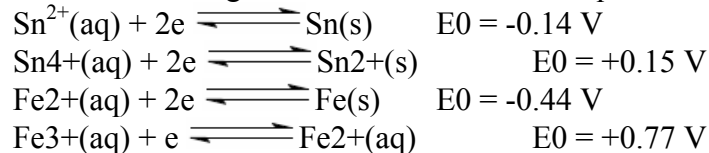
**SECTION A**

This section consists of **THIRTY (30)** multiple choice questions. Answer **ALL** questions in this section.

1. Which of the following has no permanent dipole moments?
  - a.  $\text{CHCl}_3$
  - b.  $\text{CH}_2\text{Cl}_2$
  - c.  $\text{C}_2\text{Cl}_4$
  - d.  $\text{C}_2\text{HCl}_3$
2. Which is the most abundant element in the universe?
  - a. Hydrogen
  - b. Helium
  - c. Carbon
  - d. Oxygen
3. Which one of the following equilibrium mixture will not be affected by a change in pressure?
  - a.  $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}(\text{g}) \rightleftharpoons \text{CH}_3\text{CH}=\text{CH}_2(\text{g}) + \text{H}_2\text{O}(\text{g})$
  - b.  $\text{BaCO}_3(\text{s}) \rightleftharpoons \text{BaO}(\text{s}) + \text{CO}_2(\text{g})$
  - c.  $\text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightleftharpoons 2\text{HCl}(\text{g})$
  - d.  $\text{O}_2(\text{g}) + 2\text{Hg}(\text{l}) \rightleftharpoons 2\text{HgO}(\text{s})$

4. Calcium with elemental chlorine yields calcium chloride. Write a balanced chemical equation for this reaction.
- $\text{Ca(s)} + \text{Cl}_2(\text{g}) \rightarrow \text{CaCl(s)} + \text{Cl(g)}$
  - $\text{Ca(s)} + \text{Cl}_2(\text{g}) \rightarrow \text{CaCl}_2(\text{s})$
  - $\text{Ca(s)} + 2 \text{Cl}_2(\text{g}) \rightarrow \text{CaCl}_4(\text{s})$
  - $2 \text{Ca(s)} + \text{Cl}_2(\text{g}) \rightarrow 2 \text{CaCl(s)}$
5. On heating, 0.09 mole of an element M reacts with 0.135 mole of oxygen gas. The empirical formula of the oxide of M is
- $\text{M}_2\text{O}_2$
  - $\text{M}_3\text{O}_2$
  - $\text{M}_4\text{O}_6$
  - $\text{M}_2\text{O}_3$
6. Given that  $\Delta H_f^\circ(\text{FeCl}_2(\text{s})) = -341.8 \text{ kJ/mol}$  and that  $\Delta H_f^\circ(\text{FeCl}_3(\text{s})) = -399.5 \text{ kJ/mol}$ , what is  $\Delta H_{rxn}$  for the reaction:  $\text{FeCl}_2(\text{s}) + \frac{1}{2} \text{Cl}_2(\text{g}) \rightarrow \text{FeCl}_3(\text{s})$
- 57.7 kJ
  - +714.3 kJ
  - 0 kJ
  - +57.7 kJ
7. Iron has a atomic number of 26. What is the electron configuration of the iron in  $\text{FeCl}_3$ ?
- $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3 4s^2$
  - $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$
  - $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$
  - $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$
8. A microwave oven emits radiation at a wavelength of 0.500 cm. What is the frequency of this radiation?
- $1.67 \times 10^{-11} \text{ s}^{-1}$
  - $6.67 \times 10^{-7} \text{ s}^{-1}$
  - $6.00 \times 10^{10} \text{ s}^{-1}$
  - $2.00 \text{ s}^{-1}$
9. The radioactive decay of sodium-24 has a half-life of 14.66 hours. How many grams of the radioactive sodium-24 will be left after 73 hours if the initial weight of the sample is 4g?
- 0.125g
  - 0.032g
  - 0.064g
  - 0.26g

10. Use the following information to answer the question below:



Under standard conditions, which of the following statements is correct?

- Sn(s) can reduce Fe(s)
  - Fe(s) can oxidize Sn<sup>2+</sup>(aq)
  - Sn<sup>2+</sup>(aq) can reduce Fe<sup>3+</sup>(aq)
  - Fe<sup>3+</sup>(aq) can reduce Sn<sup>4+</sup>(aq)
11. What is the pH of a solution of HNO<sub>3</sub> with a concentration of 0.0013M?
- 2.89
  - 6.64
  - 1.30
  - 11.10
12. The maximum number of electrons in the shell having the principle quantum number of n = 3 is
- 18
  - 26
  - 28
  - 36
13. The hybridization of the nitrogen atom in the molecule NF<sub>3</sub> is
- sp<sup>2</sup>
  - spd
  - sp<sup>3</sup>
  - sp<sup>3</sup>d
14. Which of the following statements is true about the elements in Group II of the Periodic Table?
- The ionic radius decreases down the group
  - The electronegativity decreases down the group
  - They form stable oxidation states of two and four
  - The atomic radius increases down the group

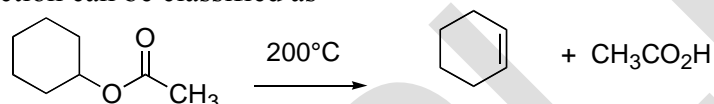
15. The oxidation number of Chromium in the ion  $\text{CrO}_4^{2-}$

- a. +4
- b. +7
- c. +6
- d. +3

16. Which of the following compounds would react most rapidly with  $\text{NaCN}$ ?

- a. 1-bromobutane
- b. (R)-2-bromobutane
- c. (S)-2-bromobutane
- d. 1-bromo-2-methylpropane

17. The following reaction can be classified as

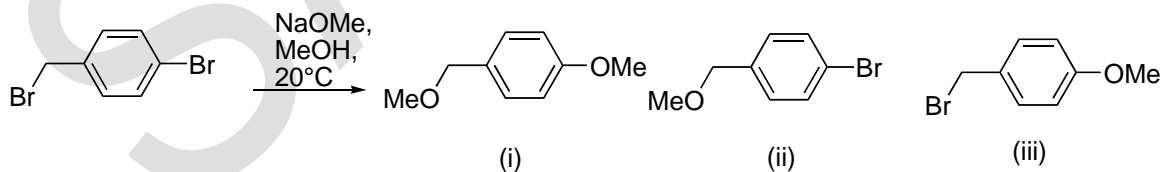


- a. elimination
- b. substitution
- c. oxidation
- d. rearrangement

18. Reaction of benzene with benzoyl chloride and aluminium trichloride will give as the product:

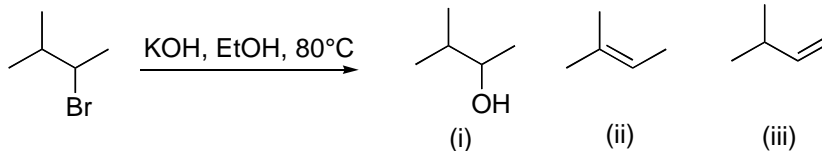
- a. benzophenone
- b. chlorobenzene
- c. no reaction
- d. benzoic acid

19. What will be the product(s) of the following reaction:



- a. (iii) only
- b. (ii) only
- c. (i) and (ii)
- d. (i), (ii) and (iii)

20. What will be the product(s) of the following reaction



- a. (i) only
- b. (ii) only
- c. (ii) and (iii)
- d. (iii) only

21. Phosphorus forms three well known compounds containing chlorine: phosphorus trichloride ( $\text{PCl}_3$ ), phosphorus pentachloride ( $\text{PCl}_5$ ) and phosphorus oxychloride ( $\text{POCl}_3$ ). What are the oxidation numbers of phosphorus in the compounds?

	$\text{PCl}_3$	$\text{PCl}_5$	$\text{POCl}_3$
a.	-3	-5	-5
b.	+1	+1	+3
c.	+3	+5	+4
d.	+3	+5	+5

22. Which of the following is the formula for a covalent network?

- a.  $\text{N}_2\text{O}_4$
- b.  $\text{P}_4\text{O}_{10}$
- c.  $\text{CO}_2$
- d.  $\text{SiO}_2$

23. Which of the following is a pure compound?

- a. Milk
- b. Ice cream
- c. Lava
- d. Distilled water

24. Which of the following electron configurations represents the ground state of an element?

- a.  $[\text{Ne}]3s^13p^1$
- b.  $[\text{He}]2s^12p^3$
- c.  $[\text{Ne}]3s^23p^33d^1$
- d.  $[\text{Ne}]3s^23p^3$

25. Formic acid ( $\text{HCO}_2\text{H}$ ) has  $K_a = 1.8 \times 10^{-4}$ . What is the value of  $K_b$  for the formate ion ( $\text{HCO}_2^-$ )?

- a.  $-1.8 \times 10^{-4}$
- b.  $1.8 \times 10^{10}$

- c.  $5.6 \times 10^{-11}$
- d.  $5.6 \times 10^4$

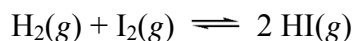
26. Which of the following molecules/ions has non-zero dipole moments?

- a. *cis*-HCIC=CHCl
- b. O<sub>2</sub>
- c. BF<sub>3</sub>
- d. ICl<sub>4</sub><sup>-</sup>

27. An increase in temperature increases the reaction rate because

- a. a greater fraction of the collisions have the correct orientation of molecules
- b. the activation energy of the reaction will decrease.
- c. temperature acts as a catalyst in chemical reactions.
- d. more collisions will have enough energy to exceed the activation energy.

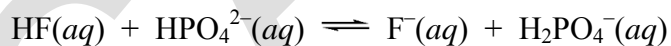
28. Calculate the equilibrium constant for the reaction using the provided equilibrium concentrations.



$$[\text{H}_2] = 0.0057 \text{ mol L}^{-1}, [\text{I}_2] = 0.0057 \text{ mol L}^{-1}, [\text{HI}] = 0.0345 \text{ mol L}^{-1}$$

- a.  $9.4 \times 10^{-4}$
- b. 0.027
- c. 37
- d.  $1.1 \times 10^3$

29. In the following reaction:



- a. HF is an acid and F<sup>-</sup> is its conjugate base.
- b. HF is an acid and HPO<sub>4</sub><sup>2-</sup> is its conjugate base.
- c. HPO<sub>4</sub><sup>2-</sup> is an acid and H<sub>2</sub>PO<sub>4</sub><sup>-</sup> is its conjugate base.
- d. H<sub>2</sub>PO<sub>4</sub><sup>-</sup> is an acid and F<sup>-</sup> is its conjugate base.

30. The ionization energies (IE) of Ti are as follows:

I	II	III	IV	V
6.82	13.58	27.49	43.27	99.22 eV

Stable oxidation states are expected when the difference in successive IE's exceeds 12 eV for valence electrons. What stable oxidation states are expected for Ti?

- Ti(I) only
- Ti (I) and Ti(V)
- Ti(I), Ti(II) and Ti(IV)
- Ti(II), Ti(III) and Ti(IV)

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## **SECTION B**

This section consists of **FOUR (4)** questions. Answer **ALL** questions in this section. This sample paper only shows 3 questions for reference only.

- Using dots to represent electrons, draw the electron distribution diagram (Lewis structure) of  $\text{ClF}_3$ . Use Valence Shell Electron Pair Repulsion theory (VSEPR) to explain the shape of this molecule.
  - Draw and label all the valence orbitals found in chlorine atom.

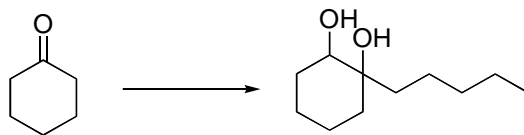
2. Data for the reaction  $2 \text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2 \text{NO}_2(\text{g})$  are given in the table.

Experiment	Concentration (mol/L)		Initial Rate (mol/L · h)
	[NO]	[O <sub>2</sub> ]	
1	$3.6 \times 10^{-4}$	$1.04 \times 10^{-2}$	$3.8 \times 10^{-8}$
3	$1.8 \times 10^{-4}$	$1.04 \times 10^{-2}$	$1.7 \times 10^{-8}$
4	$1.8 \times 10^{-4}$	$5.2 \times 10^{-3}$	?

- Determine the rate constant and write down the rate equation for the above reaction.
  - What is the initial rate of the reaction in experiment 4?
- Discuss the difference in reactivity between the following pairs of compounds under the conditions given
      - benzene and phenol with bromine
      - 1-hexanol and 2-hexanol with chromium trioxide in acid
      - ethylamine and acetamide with dilute hydrochloric acid

(iv) sodium methoxide and sodium t-butoxide with 1-bromopropane

(b) How would you carry out the following transformation? More than one step may be required.



- END OF PAPER -

SAMPLE