JOINT UNIVERSITIES PRELIMINARY EXAMINATIONS BOARD

JUNE 2020 EXAMINATIONS

JUPEB/005E

CHEMISTRY **SCI – J153** **Time Allowed: 3 Hours**

SECTION A: MULTIPLE CHOICE QUESTIONS

Answer all questions in this section.

Use the OMR answer sheet provided to answer the questions. Follow the instructions on the OMR sheet.

SECTION B: ESSAY QUESTIONS

Answer FOUR questions; ONE question from each course.

SECTION A: MULTIPLE CHOICE QUESTIONS

Answer All Questions.

1. Which of the following statements is incorrect?
   A. An atom is electrically neutral
   B. the size of a cation is smaller than that of the corresponding atom
   C. The size of an anion is bigger than that of the corresponding atom
   D. An atom and its ion have an unequal number of protons

2. Bronsted-Lowry base is
   A. an electron pair acceptor.
   B. a proton acceptor.
   C. an electron pair donor.
   D. a proton donor.

3. Which rule states that no two electron in an atom can have the same set of quantum numbers?
   A. Hund's rule
   B. Aufbau's principle
   C. de Broglie hypothesis
   D. Pauli's exclusion principle

4. Calculate the relative molecular mass of a gaseous compound if 13.15 g of the compound occupies 4.80 dm^3 at STP.
   A. 61
   B. 34
   C. 24
   D. 29

5. Which one of the following species has the same electronic configuration as Al^{3+} ion?
   A. F^-
   B. Cl^-
   C. S^{2-}
   D. O^-

6. What is the volume of oxygen required to burn completely 45cm^3 of methane?
   A. 400 cm^3
   B. 180 cm^3
   C. 90 cm^3
   D. 22.5 cm^3

7. Which of the following is TRUE regarding a precipitation reaction?
   A. Both products must be soluble in water
   B. At least one of the products will be insoluble in water
   C. At least one of the reactants must be insoluble in water
   D. Spectator ions form insoluble salts

8. Arrange the following in the order of increasing boiling point: CH_4, HCN, CaO
   A. $CH_4 < HCN < CaO$
   B. $HCN < CH_4 < CaO$
   C. $CH_4 < CaO < HCN$
   D. $CaO < CH_4 < HCN$

9. The electronegativity values of Si and H are 1.8 and 2.1 respectively. What type of bond exist within SiH_4?
   A. Ionic
   B. Polar covalent
   C. Coordinate covalent
   D. Non-polar bond

10. When an atom is oxidised, its oxidation number
   A. decreases, as electrons are gained
   B. decreases, as electrons are lost
   C. increases, as electrons are gained
   D. increases, as electrons are lost

11. What mass of carbon dioxide is formed when 60.0 g of carbon is burned in 750.0 g of oxygen? [C = 12, O = 16]
    A. 60.0 g
    B. 160.0 g
    C. 220.0 g
    D. 1031 g

12. A solution capable of resisting change in pH upon the addition of small amount of acid or base is
    A. an aqueous solution.
    B. a colloidal solution.
    C. a buffer solution.
    D. super saturated solution.

13. What is the percentage by mass of carbon present in 6.0 g of a hydrocarbon which burns completely in air to produce 11.0g of carbon dioxide? [C = 12, O = 16]
    A. 25%
    B. 33%
    C. 50%
    D. 75%

14. In which of the following species is sp^2 hybrid orbitals NOT involved?
    A. PCl_3
    B. BF_3
    C. C_2H_4
    D. CO_2

15. Calculate the standard e.m.f. in volts of a cell that uses the following half-cell reactions:
    $Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)$ $E^{\circ}Fe^{2+}/Fe = -0.44v$
    $Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s)$ $E^{\circ}Ni^{2+}/Ni = -0.25v$
    A. 0.18

B. 0.69

C. 0.11

D. 0.19

16. What is the oxidation number of oxygen in Na_2O_2?

A. -1

B. $+1$

C. -2

D. $+2$

17. If the enthalpy of a given reaction is $-215\ kJmol^{-1}$ and the entropy change of the reaction is 15.2 $Jmol^{-1}\ K^{-1}$ at 30 ^0C, then the reaction will

A. not be spontaneous

B. be spontaneous

C. be irreversible

D. be at equilibrium

18. The temperature and pressure at which the three phases of pure water coexist respectively are

A. 273 K and 760 mmHg

B. 298 K and 1 atm.

C. 0.01 ^{0}C and 4.5 mmHg

D. 0.273 ^{0}C and 0.1 mmHg

19. The pH of buffer solution depends upon concentration of

A. conjugate acid

B. conjugate base

C. salt

D. conjugate acid and base

20. What is the mole fraction of oxygen gas in a mixture containing 32.0g of oxygen gas, 32.0g of methane gas and 32.0g of sulphur (IV) oxide?
[C = 12, O = 16, H = 1, S = 32]

A. 0.143

B. 0.286

C. 0.333

D. 0.572

21. At 17°C a sample of hydrogen gas occupies 125cm^3, what will the volume be at 100°C, if the pressure remains constant?

    A. 21 cm^3

    B. 97 cm^3

    C. 161 cm^3

    D. 735 cm^3

22. Why is the first ionization energy of phosphorus greater than that of silicon?

    A. The outer electron in phosphorus is paired

    B. The atomic radius of a phosphorus atom is greater

    C. A phosphorus atom has one more proton in its nucleus

    D. The outer electron in a phosphorus is more shielded

23. Which of the following pairs exhibit the most similar chemical properties?

    A. Li and Mg

    B. Ca and Zn

    C. B and C

    D. N and O

24. Which of the following metals is not a first row transition element?

    A. V

    B. Cd

    C. Cr

    D. Mn

25. The following ions have noble gas electronic configuration except

    A. Sr^{2+}

    B. Rb^{+}

    C. I^{-}

D. Sn^{2+}

26. Which of the following compounds is the anion most polarized?
    A. LiF
    B. LiI
    C. LiCl
    D. LiBr

27. The colligative properties of a solution are affected by
    A. Nature of the solute
    B. Concentration of solute molecules
    C. Amount of liquid
    D. Surface area of solute

28. What is the coordination number and oxidation state of the central atom in $[NiCl_2(en)_2]$?
    A. 6, 2
    B. 6, 0
    C. 4, 2
    D. 4, 4

29. Excess soil acidity caused by acid rain can be neutralized by
    A. adding more fertilizers
    B. adding molten cryolite
    C. adding brime
    D. adding quick lime

30. Which of the following is an s-block element?
    A. Cs
    B. Ar
    C. Cl
    D. He

31. Use the following data to determine the standard enthalpy change of formation for solid ICl_3.

$I_{2(s)} + Cl_{2(g)} \rightarrow 2ICl_{(s)}$ $\Delta H^{\circ} = +14$ kJ/mol

$ICl_{(s)} + Cl_{2(g)} \rightarrow ICl_{3(s)}$ $\Delta H^{\circ} = -88$ kJ/mol

A. -60 kJ/mol

B. -74 kJ/mol

C. -81 kJ/mol

D. -162 kJ/mol

32. The oxide of nitrogen used as a mild anesthetic for surgery is

A. nitrogen(IV)oxide.

B. dinitrogen(I)oxide.

C. dinitrogen tetraoxide.

D. nitrogen(II)oxide.

33. Which of these reactions in equilibrium is unaffected by a change in pressure?

A. $2O_{3(g)} \rightleftharpoons 3O_{2(g)}$

B. $PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$

C. $N_2O_4 \rightleftharpoons 2NO_2$

D. $2HI_{(g)} \rightleftharpoons H_{2(g)} + I_{2(g)}$

34. The trihalides of phosphorus reacts with water to form one of the following acids.

A. H_3PO_4

B. $H_5P_3O_{10}$

C. H_3PO_3

D. $H_4P_2O_6$

35. Which of the following hydrogen halides is the most acidic: HF, HCl, HBr, HI?

A. HF

B. HI

C. HBr

D. HCl

36. The IUPAC name for $[FeF_4(H_2O)_2]^-$ is

A. diaquatetrafluoroiron (III) ion

B. diaquatetrafluoroferrate (III) ion

C. diaquatetrafluoroiron (III)

D. diaquatetrafluoroferrate (III)

37. Reaction between a hydrazine and a carbonyl compound yields a

A. hydrazone

B. diazonium salt

C. benzaldehyde

D. phenyl hydrazine

38. Which of the following is tertiary amine?

A. $CH_3CH_2NH_2$

B. $CH_3CH_2NHCH_3$

C. $(CH_3CH_2)_2NCH_3$

D. $CH(NH_2)_3$

39. Name the following organic compound.

$$CH_3CH_2CHCH_2NH_2$$
$$\quad\quad\quad|$$
$$\quad\quad CH_2-CH_3$$

A. 3-ethylbutanamines

B. 3-methylamine pentane

C. 2-ethylbutanamine

D. 3-ethyl-4-butanamine

40. Heterolytic bond fission results in the formation of positively charged carbon species known as

A. free radicals.

B. carbanions.

C. carbonium ions.

D. carbenes.

41. The following statements are true of an electrolytic cell EXCEPT

A. It converts electric energy to chemical energy.

B. A porous partition is not needed.

C. Cathode is negative electrode while anode is positive electrode.

D. Electrodes are in separate compartment.

42. The oxidation of $CH_3CH_2CHOHCH_3$ with potassium tetraoxomanganate (VII) gives

A. $CH_3CH_2CH_2COOH$

B. CH_3CH_2COOH

C. $CH_3CH_2COCH_3$

D. $CH_3CH_2CH_2CHOH$

43. Hydrogenation of vegetable oils to produce margarine is an example of

A. addition reaction.

B. Substitution reaction.

C. Elimination reaction.

D. Redox reaction.

44. The enzyme suitable for the conversion of starch to maltose is

A. Maltase

B. zymase

C. lipase

D. diastase

45. $CH_3CH_2CHCHCH_2CH_3$ does not undergo

A. Addition reaction.

B. Substitution reaction.

C. Combustion reaction.

D. Polymerization reaction.

46. The compound with molecular formula C_5H_{12} has

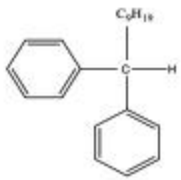
A. 2 isomers.

B. 3 isomers.

C. 4 isomers.

D. 5 isomers.

47. Consider the structure:



what electronic effect is likely to be observed?

A. Inductive effect
B. Electromeric effect
C. steric effect
D. Tautomeric effect

48. The following compounds $C_6H_{13}NH_2$, $C_3H_7NH_2$, $CH_3CH_2NH_2$, and CH_3NHCH_3 are all related as …

A. chain isomers.
B. homologues.
C. functional group isomers.
D. primary amines.

49. Which of the following reactions is suitable for the synthesis of alkenes?

A. Dehydration of primary alcohols.
B. Hydrolysis of primary alcohols.
C. Reduction of primary alcohols.
D. Oxidation of primary alcohols.

50. Branched chain isomers have the following properties when compared with their linear isomers.

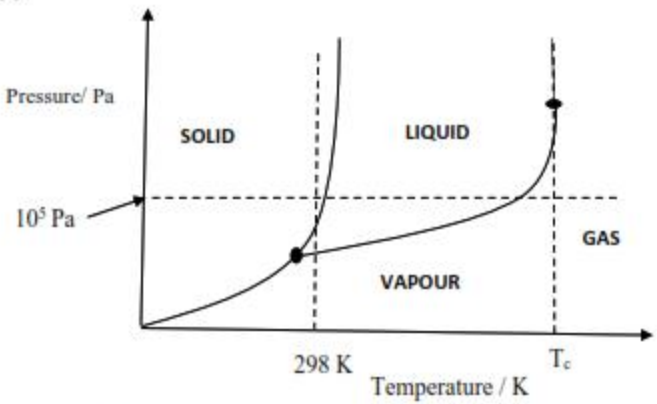
A. Low boiling point, low melting point and high density.
B. Lower boiling point, high melting point and lower density.
C. Higher boiling point, high melting point and low density.
D. Lower boiling point, low melting point and low density.

SECTION B: ESSAY QUESTIONS

Answer FOUR Questions; ONE Question from each Course.

CHM 001: GENERAL CHEMISTRY

1. (a)



The phase diagram above is for a one-component system, Z.

i. What is T_c?

ii. Under what condition will Z sublime?

iii. What phase does Z exist as at 298K and 10^5Pa? **[3 marks]**

(b) The atomic mass of a naturally occurring element Y is 55.8. The masses of the isotopes of the element are ^{54}Y and ^{57}Y.

i. Calculate the percentage abundance of each isotopes.

ii. Deduce the isotopic mass ratio. **[3 marks]**

(c) Balance the redox reaction below in alkaline medium and identify the oxidizing and reducing agents. $I^- + MnO4^- \rightarrow IO_3^- + MnO_2$ **[4 marks]**

[Total = 10 marks]

2. (a) In an experiment, 15.0g of methanol and 10.0g of carbon (II) oxide where placed in a reaction vessel. [C = 12, H = 1, O = 16]

$$CH_3OH_{(l)} + CO_{(g)} \longrightarrow HC_2H_3O_{2(1)}$$

i. Determine which reactant is the limiting reactant.

ii. From (i) above, calculate the theoretical yield of acetic acid.

iii. If the actual yield is 19.1g, what is the percentage yield? **[4 marks]**

(b) i. Distinguish between a polar and non-polar molecule.

ii. State which of the following molecules is/are polar or non-polar.

(a) CCl_4 (b) HF (c) CO_2 (d) $CHCl_3$ **[3 marks]**

(c) i. Define the term degeneracy as it applies to atomic orbitals.

ii. Give the values of the azimuthal and magnetic quantum number of the electrons in an atom when n = 4. **[3 marks]**

[Total = 10 marks]

CHM 002: PHYSICAL CHEMISTRY

3. (a) i. What are fuel cells?

ii. With the aid of equations, state the reactions that occur at the anode and cathode of H_2/O_2 fuel cell. **[3 marks]**

(b) Calculate the standard enthalpy change for the reaction:

$$CH_{4(g)} + Cl_2 \rightarrow CH_3Cl(g) + HCl_{(g)}$$

given the following bond enthalpies at 298K: **[3 marks]**

Bonds	ΔH_e/ KJmol^{-1}
C-H	+411
Cl-Cl	+243
C-Cl	+327
H-Cl	+431

(c) The decay series of $\mathbf{U}_{9}^{238}$ is shown below;'

$$^{238}_{92}U \xrightarrow[2\text{ - Beta}]{2\text{ - alpha}} Z \xrightarrow{A} {}^{222}_{86}R \xrightarrow{Q} {}^{211}_{82}Pb$$

i. State the mass and atomic number of Z.

ii. Identify the types of radiation represented by A and Q. **[3 marks]**

[Total = 10 marks]

4. (a) 2 g of He, 3 g of N_2 and 4 g of Ar were introduced into a 15 dm^3 vessel at 100 °C.

i. What are the mole fractions of He, N_2 and Ar in the system?

ii. Calculate the total pressure of the system and hence the partial pressures of each of the gases in the vessel.
[1atm=101325Nm^{-2}, He=4.0, N=14.0, Ar=39.9] **[4 marks]**

(b) i. The dissociation constant for an acid is a measure of its strength. Use the information below to arrange the following acids in order of increasing acidity.

Acid	K_a(moldm^{-3})
CH_3CH_2COOH	$1.259x10^{-5}$
$CH_3CHClCOOH$	$1.585x10^{-3}$
CH_3CCl_2COOH	$3.982x10^{-2}$
CH_2ClCH_2COOH	$7.943x10^{-5}$

ii. Suggest a reason for your arrangement. **[2 marks]**

(c) i. Differentiate between ideal and non-ideal solutions.

ii. How does the solution of a non-volatile solute affect the following properties?

(a) Vapour pressure lowering

(b) Freezing point depression **[4 marks]**

[Total = 10 marks]

CHM 003: INORGANIC CHEMISTRY

5. (a) i. Use balanced chemical equations to illustrate what happens when the following compounds are added to water.

(a) NaCl

(b) SO_3

(c) Al_2O_3

(d) Na_2O

ii. Predict the pH of the solutions. **[4 marks]**

(b) i. Explain giving reasons the trend in the solubility of group 2 sulphates.

ii. Arrange the sulphates in order of increasing solubility **[3 marks]**

(c) i. List four (4) greenhouse gases.

ii. State the source of environmental impact of any of any two in c(i) above.

[3 marks]

[Total = 10 marks]

6. (a) i. State two properties of water that are different from the hydrides of group 16

ii. Why are the first ionization energies of the d-block metals greater than those of the s-block metals? **[4marks]**

(b) i. List three types of hydrides and give example of each.

ii. Give balanced chemical equations for the reaction of two types of hydrides with water. **[5 marks]**

(c) Name the ore from which Aluminium can be extracted **[1mark]**

[Total = 10 marks]

CHM 004: ORGANIC CHEMISTRY

7. (a) i. Give two (2) differences between nucleophilic substitution unimolecular (S_N1) and nucleophilic substitution bimolecular (S_N2) reaction. **[2 marks]**

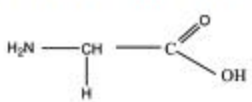
(b) There are several isomers with the molecular formula $C_5H_{12}O$.

i. Provide the structures and names of three unbranched isomers of the alkanol with formula $C_5H_{12}O$.

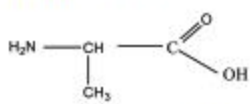
ii. Which isomer(s) is/are chiral?

iii. Write a chemical equation for each compound in (b)i with excess acidified $K_2Cr_2O_7$ and provide names for the products formed. **[5 marks]**

(c) Below are the structures of two natural amino acids



Glycine



Alanine

i. Draw a structure of the compound formed when glycine is

combined with alanine

ii. What class of compound in formed in i, above?

iii. What type of bond is obtained?

iv. Draw the zwitterionic forms of glycine and alanine **[3 marks]**

[Total = 10 marks]

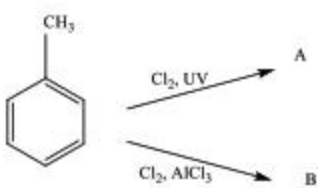
8. (a) An organic compound F, with the empirical formular, $C_5H_{10}O$ has a vapour density of 43.

i. What is the molecular formula of F?

ii. If F does not react with Fehling's or Tollen's reagent but gives a yellow precipitate when reacted with aqueous iodine, draw the structure and give the IUPAC name of F

iii. Write a reaction equation for the reduction of F with $NaBH_4$ **[3 marks]**

(b) Methyl benzene can react with chlorine in two ways. The products formed in each case depends on the reaction conditions.



i. Draw the structures of A and B

ii. Predict the products for the reaction of A and B with NaOH **[2 marks]**

iii. Write a balanced equation and name the product(s) formed when;

(a) $CH_3CH_2COCH_2CH_2CH_3$ reacts with $LiAlH_4$

(b) Benzene reacts with CH_3Cl

(c) CH_3CH_2OH reacts with $CH_3CH_2CH_2COOH$ **[3 marks]**

(c) Arrange the following carboxylic acids in order of increasing acidity. Justify your answer. 3-chloropentanoic acid; pentanoic acid; 2, 2-dichloropentanoic acid; 3,3-dichloropentanoic acid; 2-chloropentanoic acid; 4-chloropentanoic acid. **[2 marks]**

[Total = 10 marks]