

Chemistry, 2014 EC, natural science, entrance exam, round 1

Grade 12 · Chemistry · 2014 E.C.

MARKING KEY — CONFIDENTIAL

Time allowed: 120 minutes

Questions: 58

Total marks: 58

1. What is the difference between reversible and irreversible reactions? (1)
- A. In reversible reactions, the reaction goes to completion.
- B. In irreversible reactions, there is a mixture of products and reactants.
- C. ✓ **In reversible reactions, there is equilibrium between reactants and products.**
- D. In irreversible reactions, there is equilibrium between reactants and products.

Answer: C

In a reversible reaction, reactants and products coexist in a state of dynamic chemical equilibrium where the forward and reverse reactions occur at equal rates, unlike irreversible reactions which go to completion.

2. Consider the reactions all given below are in gaseous state. For which of the following reactions is K_p less than K_c ? (1)
- A. $N_2O_4 \rightleftharpoons 2NO_2$
- B. ✓ **$2SO_2 + O_2 \rightleftharpoons 2SO_3$**
- C. $2H_2 \rightleftharpoons H_2 + I_2$
- D. $N_2 + O_2 \rightleftharpoons 2NO$

Answer: B

The relationship between the equilibrium constants is given by $K_p = K_c(RT)^{\Delta n}$. For reaction B ($2SO_2 + O_2 \rightleftharpoons 2SO_3$), the change in moles of gas is $\Delta n = 2 - 3 = -1$, which makes $K_p < K_c$.

3. The general formula for saturated monocarboxylic acids is (1)
- A. ✓ **$RCOOH$**
- B. $RCOR$
- C. $RCHO$
- D. ROR

Answer: A

Saturated monocarboxylic acids (also known as alkanolic acids) contain one carboxyl group ($-COOH$) attached to an alkyl group, represented by the general formula $RCOOH$.

4. What is enthalpy change? It is (1)
- A. the amount of heat given out or absorbed in a reaction at constant pressure and volume
- B. the amount of heat absorbed in a reaction
- C. the amount of heat given out in a reaction
- D. ✓ **the amount of heat given out or absorbed in a reaction at constant pressure**

Answer: D

Enthalpy change (ΔH) is defined as the amount of heat energy absorbed or released by a chemical system during a process occurring at constant pressure ($q_p = \Delta H$).

5. What is oxidation? Oxidation is (1)
- A. the addition of electron(s) to the oxidizing agent
 - B. the reduction of the oxidation state of the oxidizing agent
 - C. the addition of hydrogen to a substance and the removal of oxygen from a substance
 - D. ✓ **the loss of electrons by a species, accompanied by an increase in oxidation number**

Answer: D

Oxidation is defined as the process in which an atom, ion, or molecule loses one or more electrons, which corresponds to an increase in its oxidation number.

6. What is meant by preferential discharge, if a number of ions are present in a solution? It means that the one which requires (1)
- A. highest energy will be liberated first at a given electrode
 - B. highest energy will be liberated last at a given electrode
 - C. ✓ **least energy will be liberated first at a given electrode**
 - D. least energy will be liberated last at a given electrode

Answer: C

Preferential discharge refers to the selective reduction or oxidation of ions at an electrode during electrolysis; the ion that requires the least energy to gain or lose electrons is discharged first.

7. Which of the following is a property of covalent compounds? Covalent compounds (1)
- A. ✓ **is generally insoluble in water**
 - B. is crystalline solids at room temperature
 - C. is non-volatile
 - D. has high melting and boiling points

Answer: A

Unlike ionic compounds, covalent compounds are generally nonpolar and thus insoluble in polar solvents like water. They also typically have low melting and boiling points, and are volatile.

8. Which of the following is a covalent molecule? (1)
- | | |
|--------------------------------|----------------|
| A. $[NH_4]^+$ | B. CO_3^{2-} |
| C. ✓ PCl_3 | D. $NaCl$ |

Answer: C

PCl_3 is a neutral molecule formed by covalent bonding between nonmetal phosphorus and chlorine atoms. In contrast, $NaCl$ is an ionic compound, while $[NH_4]^+$ and CO_3^{2-} are polyatomic ions.

9. What is the concentration of a solution? It is (1)
- A. the amount of solute needed to make a concentrated solution
 - B. number of moles of solute and number of moles of solvent
 - C. ✓ **the quantity of solute in a given quantity of solution**
 - D. the amount of solvent needed to dissolve a solute

Answer: C

Concentration is a quantitative measure of the amount of a solute that is dissolved in a given quantity of solvent or total solution.

15. How is tanning carried out? In tanning the hides or skins are (1)
- A. ✓ **treated with chromium salts**
 - B. treated with dilute hydrochloric acid to remove the lime
 - C. soaked in water for several days
 - D. soaked in lime and water for several days

Answer: A

Tanning is the chemical process that permanently alters the protein structure of skins. Chrome tanning, which is the most common method, involves treating the hides with chromium salts.

16. How can a project of establishing an industry that consumes coal affect the environment? (1)
- A. Production of high level of lead in the atmosphere
 - B. By changing the pH of water
 - C. Increment in concentration of nitric oxide
 - D. ✓ **Rise in global temperature**

Answer: D

Coal-consuming industries burn massive quantities of coal, releasing carbon dioxide (CO_2), which is a greenhouse gas that traps heat in the atmosphere and leads to a rise in global temperature.

17. Which of the following is a fundamental quantity SI unit? (1)
- A. Pressure
 - B. ✓ **Length**
 - C. Speed
 - D. Force

Answer: B

Length is one of the seven fundamental base physical quantities defined in the International System of Units (SI). Pressure, speed, and force are derived quantities.

18. Which of the following postulates of Dalton's atomic theory was modified by the modern atomic theory? (1)
- A. Atoms are neither created nor destroyed in chemical reactions
 - B. Compounds are formed when atoms of more than one element combine
 - C. Atoms are the smallest particles of all elements
 - D. ✓ **Atoms are indivisible and indestructible**

Answer: D

Dalton's postulate that atoms are indivisible and indestructible was modified by modern atomic theory following the discovery of subatomic particles (protons, neutrons, and electrons).

19. Which of the following includes all of the known atomic models? (1)
- A. Bohr Model, Rutherford Mechanical Model
 - B. Thomson Model, Dalton's Atomic Model
 - C. ✓ **Bohr Model, Thomson Model, Rutherford Model, Dalton's Atomic Model**
 - D. Valence Bond Model, Quantum Mechanical Model, Thomson Model, Rutherford Model

Answer: C

This list accurately includes the main historical atomic models in chronological order: Dalton's billiard ball model, Thomson's plum pudding model, Rutherford's nuclear model, and Bohr's planetary model.

20. What does Mendeleev's Periodic Law state? Properties of elements are (1)
- A. periodic functions of their electron configurations
 - B. atomic radius
 - C. atomic numbers
 - D. ✓ **atomic masses**

Answer: D

Dmitri Mendeleev formulated his periodic law stating that the physical and chemical properties of elements are periodic functions of their atomic masses, which was later updated to atomic numbers in the modern periodic law.

21. What is the mole ratio of oxygen gas to carbon dioxide gas in the following reaction? $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$ (1)
- A. 2 mole oxygen gas to 3 mole carbon dioxide
 - B. 7 mole oxygen gas to 5 mole carbon dioxide
 - C. 10 mole oxygen gas to 6 mole carbon dioxide
 - D. ✓ **5 mole oxygen gas to 3 mole carbon dioxide**

Answer: D

From the balanced chemical equation, the stoichiometric coefficients for O_2 and CO_2 are 5 and 3, respectively, which gives a mole ratio of 5 moles of oxygen gas to 3 moles of carbon dioxide gas.

22. Consider the following chemical equation for the combustion of ethane (C_2H_6) in the presence of oxygen to produce carbon dioxide and water: $C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(l)$ In this reaction: (1)
- A. Water is formed at a rate equal to 2/3 the rate of formation of CO_2
 - B. ✓ **CO_2 is formed twice as fast as ethane is consumed**
 - C. The rate of consumption of ethane is 7 times faster than the rate of consumption of oxygen
 - D. The rate of formation of CO_2 equals the rate of formation of water

Answer: B

In the balanced chemical equation for the combustion of ethane ($2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$), the stoichiometric coefficient of CO_2 (4) is twice that of ethane (2). Therefore, the rate of formation of carbon dioxide is twice the rate of consumption of ethane.

23. Which of the following factors DOES NOT affect the rate of a reaction? (1)
- A. Temperature
 - B. ✓ **Enthalpy**
 - C. Concentration
 - D. Surface area

Answer: B

Enthalpy (ΔH) is a thermodynamic property that describes the heat change of a reaction, but it does not affect the rate of a chemical reaction, which is determined by kinetic factors such as temperature, concentration, and surface area.

24. How does a catalyst increase the rate of a reaction? (1)
- A. ✓ **By lowering the activation energy**
 - B. By changing the equilibrium constant
 - C. By forming an intermediate complex
 - D. By increasing the activation energy

Answer: A

A catalyst increases the rate of a chemical reaction by providing an alternative reaction pathway with a lower activation energy, allowing more reactant molecules to have sufficient energy to react.

25. Which of the following statements correctly describes Boyle's Law? (1)
- A. The volume of a gas at a given temperature is proportional to the square root of the applied pressure
 - B. The volume of a gas at a given temperature is inversely proportional to the square root of the applied pressure
 - C. The volume of a gas at a given temperature is directly proportional to the applied pressure
 - D. ✓ **The volume of a gas at a given temperature is inversely proportional to the applied pressure**

Answer: D

Boyle's Law states that at a constant temperature, the volume of a given mass of gas is inversely proportional to its pressure ($V \propto 1/P$).

26. What are intermolecular forces? They are forces due to the attraction between (1)
- A. nuclei and electron pair
 - B. cations and delocalized electrons
 - C. ✓ **molecules**
 - D. cations and anions

Answer: C

Intermolecular forces are weak attractive forces that exist between neighboring molecules, in contrast to intramolecular forces (like covalent bonds) which hold atoms together within a single molecule.

27. Which of the following belongs to chemical bonding theories? (1)
- A. Molecular orbital theory and kinetic-molecular theory
 - B. Valence bond theory and valence shell electron pair repulsion theory
 - C. Kinetic-molecular theory and valence shell electron pair repulsion theory
 - D. ✓ **Valence bond theory and molecular orbital theory**

Answer: D

Valence Bond Theory (VBT) and Molecular Orbital Theory (MOT) are the two primary quantum-mechanical theories used to explain chemical bonding and molecular structure.

28. In which of the following molecules is the central atom sp² hybridized? (1)
- A. ✓ **SO₂**
 - B. CO
 - C. CO₂
 - D. N₂O

Answer: A

In sulfur dioxide (SO₂), the central sulfur atom has two σ-bonds and one lone pair, giving it a steric number of 3, which corresponds to sp² hybridization.

29. The half-life of a reaction is the time taken for the (1)
- A. rate constant to decrease by 50% of its initial value
 - B. complete conversion of a reactant into a product
 - C. ✓ **reactant concentration to decrease by 50% of its initial value**
 - D. rate constant to increase by 50% of its initial value

Answer: C

The half-life ($t_{1/2}$) of a reaction is defined as the time required for the concentration of a reactant to decrease to half (50%) of its initial concentration.

30. In the scientific method, a predictive statement that can be tested experimentally is: (1)
- A. proof
B. ✓ hypothesis
C. truth
D. evidence

Answer: B

In the scientific method, a hypothesis is a tentative, testable, and predictive statement proposed to explain a set of observations.

31. Which of the following is NOT true about cathode rays? Cathode rays (1)
- A. ✓ contain particles, which are positively charged
B. are common constituents of all matter and their m/e is constant for all gases
C. contain particles, which are negatively charged
D. travel in straight lines from cathode to the anode

Answer: A

Cathode rays consist of electrons, which are negatively charged particles, making statement A incorrect and thus the correct choice.

32. Which of the following statements is correct about the energy of a photon? (1)
- A. It is directly related to the intensity of the light
B. It is directly proportional to the wavelength of the light
C. ✓ It is directly proportional to the observed frequency of the light
D. It is inversely proportional to the observed frequency of the light

Answer: C

According to Planck's equation, $E = h\nu$, the energy of a photon is directly proportional to its frequency (ν).

33. Which of the following explains the emission spectra of atoms consisting of a series of fine lines? (1)
- A. The energy of the atoms is continuous with discrete frequencies
B. An electron that revolves around the nucleus emits specific energy values in an atom
C. An electron can have specific transition by energy changes corresponding to photon of specific wavelength
D. ✓ An electron undergoes a transition by energy changes corresponding to photon of specific wavelength

Answer: D

Atomic emission spectra consist of discrete fine lines because electrons undergo transitions between quantized energy levels, emitting photons with specific wavelengths that correspond to the energy difference between those levels.

34. Which of the following is a polyprotic acid? (1)
- A. HF
B. HNO₃
C. HCl
D. ✓ H₃PO₄

Answer: D

Phosphoric acid (H_3PO_4) is a polyprotic (specifically, triprotic) acid because it has three ionizable hydrogen atoms that can be donated in successive steps.

35. Which of the following does represent a general property of a base? (1)
- A. Soluble bases release hydronium ion in aqueous solution
 - B. Aqueous solution of bases turns methyl orange to red
 - C. ✓ **Solutions of strong bases are good conductors of electricity**
 - D. Aqueous solution of bases turns blue litmus paper to red

Answer: C

Strong bases completely dissociate into ions in aqueous solution, making them strong electrolytes that conduct electricity very efficiently.

36. What are salts? Salts are (1)
- A. ✓ **Ionic compounds that derive their cations from a base and their anions from an acid**
 - B. Ionic compounds formed by partial replacement of ionizable hydrogen by metal cations
 - C. Ionic compounds formed by complete replacement of ionizable hydrogen by anions of the acid
 - D. Ionic compounds that result from the reaction between metal hydroxide and water

Answer: A

A salt is an ionic compound composed of cations (which typically originate from a base) and anions (which typically originate from an acid).

37. The process in which a compound absorbs electrical energy and decomposes into its elements is (1)
- A. hydrolysis
 - B. electropating
 - C. ✓ **electrolysis**
 - D. solvolysis

Answer: C

Electrolysis is the process in which electrical energy is used to drive a non-spontaneous chemical reaction, causing a compound to decompose into its elements.

38. Which of the following is true about galvanic cells used in commercial lead storage batteries? In lead storage batteries, (1)
- A. half of the galvanic cells are connected in series
 - B. the galvanic cells are made up of PbO 2 of anodes
 - C. ✓ **galvanic cells are connected in series**
 - D. galvanic cells are connected in parallel

Answer: C

In commercial lead storage batteries, multiple galvanic cells (typically six cells, each producing about 2V) are connected in series to achieve a higher output voltage (like 12V).

39. Sodium carbonate is a basic salt because it is a salt of (1)
- A. a weak acid and a weak base and the cation of the weak base can be hydrolyzed
 - B. a strong acid and a weak base and the anion of the strong acid can be hydrolyzed
 - C. ✓ **a strong base and a weak acid and the anion of the weak acid can be hydrolyzed**
 - D. a strong base and a strong acid and the anion of the strong acid can be hydrolyzed

Answer: C

Sodium carbonate (Na_2CO_3) is a basic salt because it is formed from a strong base ($NaOH$) and a weak acid (H_2CO_3). The carbonate anion (CO_3^{2-}), being the conjugate base of a weak acid, undergoes hydrolysis to produce hydroxide ions (OH^-), making the solution basic.

40. Which of the following statements is true for an acid-base titration? (1)
- A. **An acid-base titration is a method of quantitative analysis for determining the concentration of an acid or base**
 - B. An acid-base titration is a method of qualitative analysis for determining the concentration of an acid or base
 - C. Indicators catalyze an acid-base titration to show the inflection point of the titration curve
 - D. Acid-base titrations cannot be carried out in the absence of indicators

Answer: A

An acid-base titration is a fundamental method of quantitative chemical analysis used to determine the unknown concentration of an acid or a base by reacting it with a standard solution of known concentration.

41. What is the change in internal energy (ΔE) for a reaction, in which the system absorbs 650 J of heat and 125 J of work is done on the system? (1)
- A. -775 J
 - B. -535 J
 - C. **✓ 775 J**
 - D. 535 J

Answer: C

According to the first law of thermodynamics, $\Delta E = q + w$. Since heat is absorbed by the system ($q = +650 \text{ J}$) and work is done on the system ($w = +125 \text{ J}$), the change in internal energy is $\Delta E = 650 \text{ J} + 125 \text{ J} = 775 \text{ J}$.

42. Which statement describes the formation of a covalent bond? In covalent bond electrons are (1)
- A. **✓ shared between non-metallic atoms**
 - B. transferred from non-metallic atoms to metallic atoms
 - C. shared between metallic atoms
 - D. transferred from metallic atoms to non-metallic atoms

Answer: A

A covalent bond is characterized by the sharing of one or more pairs of electrons between non-metallic atoms to achieve a stable outer electron shell.

43. How do the elements of Group IIA form ions? (1)
- A. **✓ By losing 2 electrons**
 - B. By gaining 2 electrons
 - C. By gaining one electron
 - D. By losing one electron

Answer: A

Group IIA (alkaline earth metals) elements have two valence electrons, which they readily lose to form stable $2+$ cations with a noble gas configuration.

44. How is hydrogen bonding formed? It is formed when a hydrogen atom is bonded to (1)
- A. highly electronegative elements, chlorine, oxygen and nitrogen
 - B. **✓ highly electronegative elements, fluorine, oxygen and nitrogen**
 - C. highly electronegative elements, fluorine, chlorine and oxygen
 - D. highly electronegative elements, fluorine, oxygen and phosphorus

Answer: B

Hydrogen bonding is a strong intermolecular force that occurs when hydrogen is covalently bonded to highly electronegative and small atoms, specifically fluorine (F), oxygen (O), or nitrogen (N).

45. Which one of the following types of energy change occurs from the combustion of carbon in oxygen? (1)

- A. ✓ heat energy B. solar energy
C. light energy D. electrical energy

Answer: A

The combustion of carbon in oxygen is a highly exothermic chemical reaction that releases energy primarily in the form of heat energy.

46. What is the molar volume of a gas? (1)

- A. The volume of a gas at STP (standard temperature 0°C and pressure,1 kPa), which is equal to 22.4 L/mol
- B. The volume of a gas at STP (standard temperature 25°C and pressure,1 kPa), which is equal to 22.4 L/mol
- C. **The volume of a gas at STP (standard temperature, 0°C and pressure,1 atm), which is equal to 22.4 L/mol**
- D. The volume of a gas at STP (standard temperature 25°C and pressure,1 atm), which is equal to 22.4 L/mol

Answer: C

The molar volume of an ideal gas at standard temperature and pressure (STP), defined as 0 °C (273.15 K) and 1 atm (101.325 kPa), is approximately 22.4 L/mol.

47. Which of the following assumptions of the kinetic molecular theory of gases explains the high compressibility of gases?

- A. Particles are always in random motion
B. Different particles have different speeds
C. ✓ **The actual volume of gas molecules is negligible**
D. There is no force of attraction between gas molecules

Answer: C

Gases are highly compressible because the actual volume of the gas molecules is negligible compared to the total volume of the gas, leaving vast amounts of empty space between the particles.

48. Consider a bottle containing water, water vapor and air in equilibrium. If the temperature decreases slightly, the amount of water vapor: (1)

- B. ✓ and vapor pressure will decrease**

Answer: B

As the temperature of the system decreases, the rate of condensation increases relative to vaporization, leading to a decrease in both the amount of water vapor and its vapor pressure.

49. Why do water droplets collect on the outside of a glass of water on a hot day? (1)

- A. ✓ **There will be a condensation of water vapor on the glass**
- B. There will be a sublimation of water vapor on the outside of a glass
- C. There is heat exchange between the water in the glass and the surrounding
- D. Water from the glass starts to vaporize

Answer: A

The formation of water droplets on the outer surface of a glass of cold water is due to the condensation of moisture (water vapor) from the warmer surrounding air when it touches the cold glass.

50. What are hydrocarbons? Compounds that contain (1)
- A. benzene rings only
 - B. benzene and its derivatives only
 - C. hydrogen and carbon with no benzene rings
 - D. ✓ **hydrogen and carbon only**

Answer: D

Hydrocarbons are defined as organic chemical compounds consisting entirely of hydrogen and carbon atoms, which can be either aliphatic or aromatic.

51. Which of the following statement is INCORRECT regarding the boiling points of alkanes? (1)
- A. Boiling points of straight chain alkanes is greater than that of branched chain alkanes
 - B. The boiling point of cycloalkanes is higher than that of linear alkanes
 - C. Boiling points increases with stronger Van der Waals forces
 - D. ✓ **Surface area is the only factor that determines the boiling points of alkanes**

Answer: D

Surface area is not the only factor that determines the boiling points of alkanes; molecular mass (number of carbon atoms) is also a major factor, with larger alkanes having higher boiling points.

52. Which of the following statements is NOT correct about minerals and ores? (1)
- A. Minerals are the natural forms in which various metals exist
 - B. Ores are usually used to extract metals economically
 - C. ✓ **All minerals are ores**
 - D. All ores are minerals

Answer: C

While all ores are minerals, not all minerals are ores. A mineral is only classified as an ore if it contains a sufficiently high concentration of a metal to make its extraction economically viable.

53. Why is CaCl_2 added to NaCl in a 1:½ ratio in the Down's cell for the manufacturing of sodium metal? (1)
- A. CaCl_2 is used to lower the density of the mixture
 - B. CaCl_2 is used as an electrolyte
 - C. CaCl_2 is used as a catalyst
 - D. ✓ **CaCl_2 is used to lower the melting temperature of NaCl**

Answer: D

Calcium chloride (CaCl_2) is added to sodium chloride (NaCl) in the Downs cell to act as an impurity that lowers the melting point of the mixture from about 801 °C to around 600 °C, conserving energy and preventing sodium vaporization.

54. Which of the following is NOT a major step in metallurgical processes? (1)
- A. Pretreatment
 - B. Extracting the metal and refining
 - C. ✓ **Mining the ore**
 - D. Concentrating the ore

Answer: C

Mining the ore is a preliminary step of physical extraction from the Earth, whereas the major chemical and physical steps of metallurgy proper include concentration (dressing), reduction (extraction), and refining.

55. Which monomers are used for the synthesis of Teflon? (1)

- A. Styrene and Phenol
B. ✓ **Tetrafluoroethylene**
C. Isoprene
D. Propylene

Answer: B

Teflon (polytetrafluoroethylene or PTFE) is synthesized by the addition polymerization of the monomer tetrafluoroethylene ($\text{CF}_2=\text{CF}_2$).

56. What is the rate of dissolution? It is (1)

- A. the rate at which a solid dissociates
B. the speed at which a solid sublimates
C. the rate at which a solid turns to liquid
D. ✓ **the speed at which a solid substrate goes into solution**

Answer: D

The rate of dissolution is defined as the speed or rate at which a solute dissolves and goes into a solvent to form a solution.

57. Which one of the following is correctly stated regarding solubility as an equilibrium process? (1)

- A. ✓ **Supersaturated solution is a solution that contains more than the equilibrium amount of dissolved solute**
B. Supersaturated solution is more stable than saturated solution
C. Unsaturated solution is a solution that is in equilibrium with respect to a given dissolved substance
D. Unsaturated solution is a solution in which more of the solute can be dissolved

Answer: A

A supersaturated solution is an unstable system containing more dissolved solute than the maximum amount that can exist in equilibrium (saturated solution) at that temperature.

58. Which of the following carboxylic acids is a solid substance at room temperature? (1)

- A. Nonanoic acid
B. ✓ **Decanoic acid**
C. Heptanoic acid
D. Octanoic acid

Answer: B

Carboxylic acids with up to 9 carbon atoms are liquids at room temperature, whereas those with 10 or more carbon atoms (such as decanoic acid, $\text{C}_{10}\text{H}_{20}\text{O}_2$) exist as wax-like solids.

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