

Chemistry, 2013 EC, natural science, entrance exam, round 1

Grade 12 · Chemistry · 2013 E.C.

MARKING KEY — CONFIDENTIAL

Time allowed: 120 minutes

Questions: 69

Total marks: 69

1. From the magnitude of the equilibrium constant, K_{eq} one can deduce that (1)
- A. ✓ **large K_{eq} value indicates that the reaction reaches equilibrium with very little reactants remaining.**
- B. Small K_{eq} values indicate the reaction yields very higher amounts of products near equilibrium.
- C. K_{eq} will be larger when we have higher amounts of reactants over products.
- D. Intermediate K_{eq} value indicates that the reaction does proceed in the forward direction.

Answer: A

A large equilibrium constant ($K_{eq} > 10^3$) indicates that the forward reaction is highly favored, meaning that at equilibrium, the mixture consists almost entirely of products with very little reactants remaining.

2. The statement 'If a system at equilibrium is subjected to a stress, the system will readjust itself to reduce the effects of the stress' is known as (1)
- A. Avogadro's principle.
- B. Faradays law.
- C. ✓ **Le-Chatelier's principle.**
- D. Boyle's law.

Answer: C

Le-Chatelier's principle states that if a dynamic equilibrium is disturbed by changing the conditions, the position of equilibrium shifts to counteract the change to re-establish an equilibrium.

3. The law of mass action states that (1)
- A. The K_{eq} expression is the ratio of the concentrations of reactants to the products raised to their coefficients.
- B. **The rate of a reaction is directly proportional to the product of the concentration of reactants raised to the power of their respective coefficients in the balanced equation.**
- C. For a reaction at equilibrium, the reaction quotient, Q is always less than the equilibrium constant, K_{eq} .
- D. A chemical equilibrium is attained only when the reaction is started with reactants.

Answer: B

The law of mass action states that the rate of a chemical reaction is directly proportional to the product of the concentrations of the reactants, each raised to a power equal to its stoichiometric coefficient in the balanced equation.

4. For the reaction between gaseous NO and O_2 to form $NO_2(g)$, what will be the equilibrium constant expression, (1)
- $$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$$
- A. $K_p = (P_{NO_2}) / (P_{NO})(P_{O_2})$
- B. ✓ **$K_c = (NO_2)^2 / (NO)^2 (O_2)$**
- C. $K_p = (P_{NO_2})^2 (P_{O_2}) / (P_{NO})^2$
- D. $K_p = (P_{NO_2})^2 / (NO)^2 (O_2)$

Answer: B

The equilibrium constant expression K_c is the ratio of the molar concentrations of products to reactants, each raised to the power of their stoichiometric coefficients. Thus, for $2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$, $K_c = [NO_2]^2 / ([NO]^2 * [O_2])$.

5. The equilibrium constant K_p for the reaction $2\text{SO}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g}) + \text{O}_2(\text{g})$ is $3.8 \times 10^{-3} K_p$ at 227°C . What is the value of K_c for the reaction at the same temperature?
- A. $4.6 \times 10^{-4} \text{ mol m}^{-3}$
- B. $1.8 \times 10^{-3} \text{ mol m}^{-3}$
- C. $2.3 \times 10^{-4} \text{ mol m}^{-3}$
- D. ✓ $9.1 \times 10^{-4} \text{ mol m}^{-3}$

Answer: D

For the reaction $2\text{SO}_3(\text{g}) \rightleftharpoons 2\text{SO}_2(\text{g}) + \text{O}_2(\text{g})$, the change in moles of gas is $\Delta n = 1$. Using $K_c = K_p / (RT)^{\Delta n}$ with $T = 500 \text{ K}$ and $R = 0.08206 \text{ L atm/(mol K)}$ yields approximately $9.1 \times 10^{-5} \text{ mol/L}$ (often misprinted with different exponents or units as $9.1 \times 10^{-4} \text{ mol m}^{-3}$).

6. In the Galvanic cell given in the diagram below Identify the component parts correctly labelled for the letters a, b, c, d and choose the correct one among the following a, b, c, and d , respectively (1)
- A. Copper anode, Zinc cathode, voltmeter , salt bridge
- B. Zinc cathode, Copper cathode, Zinc anode, Copper cathode
- C. Copper anode, Zinc anode, CuSO_4 (sol), voltmeter
- D. ✓ **Zinc anode, Copper cathode, ZnSO_4 (sol), salt bridge**

Answer: D

In a standard Daniell (Galvanic) cell, zinc acts as the anode, copper as the cathode, zinc sulfate and copper sulfate as the electrolyte solutions, and a salt bridge connects the two half-cells.

- 7.** The conversion of nitrogen gas into useful nitrogen compounds is known as
- A. Photosynthesis B. Respiration
C. Oxidation D. ✓ **Fixation**

Answer: D

Nitrogen fixation is the chemical process by which atmospheric nitrogen (N_2) is converted into ammonia or other organic nitrogen compounds, making it usable by organisms.

8. CO₂ is released into the atmosphere by one of the following processes (1)
- A. Animals eat plants and release CO₂ by photosynthesis
 - B. Plants consume atmospheric carbon dioxide during photosynthesis
 - C. Utilization of electrical energy as energy sources
 - D. ✓ **Natural fires and volcanoes release CO₂ into the air**

Answer: D

Volcanic eruptions and forest fires are natural processes that release significant amounts of carbon dioxide (CO₂) directly into the atmosphere, unlike photosynthesis which consumes it.

9. One of the following is NOT a common application of silicon (1)
- A. in the control of the frequency of television transmissions
 - B. in the construction of transistors and microprocessors
 - C. ✓ in coating iron to prevent it from rusting
 - D. in the production of polish body parts cars

Answer: C

Silicon is not used to coat iron to prevent rusting; elements like zinc (galvanization), tin, or chromium are used for this purpose instead.

10. The branch of chemistry that is involved in separation, identifying and determining the relative amounts of components in a sample of material is known as (1)

- A. ✓ **analytical chemistry**
- B. biochemistry
- C. inorganic chemistry
- D. physical chemistry

Answer: A

Analytical chemistry is the branch of chemistry focused on the separation, identification, and quantification of the chemical components of natural and artificial materials.

11. Significant figures are figures with (1)

- A. measured values with the highest accuracy
- B. measured values with the highest precision
- C. ✓ **exactly known digits with the last digit uncertain**
- D. measured values with the highest uncertainty

Answer: C

Significant figures in a measurement consist of all the digits known with certainty, plus one final digit that is estimated or uncertain.

12. For the determination of the density of a new ceramic, a student measured the mass of a piece on an analytical balance and obtained 3.8056 gram and its volume 2.5 mL by displacement of water in a graduated cylinder. The correct reported density of the ceramic should be (1)

- A. 1.5224 g/mL
- B. 1.5222 g/mL
- C. 3.5 g/mL
- D. ✓ **1.5 g/mL**

Answer: D

The volume measurement (2.5 mL) has two significant figures, so the calculated density ($3.8056 \text{ g} / 2.5 \text{ mL} = 1.52224 \text{ g/mL}$) must be rounded to two significant figures, which is 1.5 g/mL.

13. The scientific method is (1)

- A. ✓ **a method of arriving at an organized body of knowledge based on reproducible experiments and observations**
- B. a collection of scientific guesses and hypotheses by seeking patterns in the observations
- C. the result of fortunate, accidental discovery in the development of science
- D. the sum total of unique guidelines for the practice of science in the world

Answer: A

The scientific method is a systematic, empirical approach to acquiring knowledge that relies on reproducible observation, experimentation, and logical reasoning.

14. One of the following is NOT a cause of uncertainty in measurement? (1)

- A. The person doing the experiment
- B. ✓ **The type of material measured**
- C. The environment where the measurement is made
- D. The measuring device

Answer: B

While the instrument calibration, human technique, and environmental conditions directly contribute to measurement uncertainty, the inherent identity of the substance being measured does not.

15. Hydrogen bonding occurs in compounds that contain H-N, H-O and H-F bonds. These bonds are stronger than the ordinary dipole-dipole interactions because (1)
- A. the H-N, H-O and H-F bonds are less polar than ordinary covalent bonds
 - B. **the partially positive H of one molecule is attracted to the partially negative lone pairs on the N, O or F of another molecule**
 - C. the H-N, H-O and H-F bonds are non-polar and thus do not interact with neighboring molecules
 - D. the small sizes of N, O and F makes these atoms so electropositive that their covalently bonded H is highly negative

Answer: B

Hydrogen bonds are unusually strong dipole-dipole attractions because the highly electronegative N, O, or F atoms strongly pull electron density away from hydrogen, leaving a highly positive partial charge on H that strongly attracts lone pairs on adjacent molecules.

16. Which of the following is an example of exception to the octet rule? (1)
- A. CCl₄
 - B. NH₃
 - C. **✓ PCl₅**
 - D. H₂O

Answer: C

Phosphorus pentachloride (PCl₅) is an exception to the octet rule because the central phosphorus atom has 10 valence electrons in its bonding shell, representing an expanded octet.

17. When the boiling point of hydrides of group VIA elements, H₂O, H₂S, H₂Se and H₂Te are arranged in the order of increasing boiling point. The trend is H₂Te < H₂Se < H₂S < H₂O, water having the highest boiling point, this is due to (1)
- A. the basic different structures of each hydride
 - B. the small size of O compared to the other group VIA elements
 - C. **✓ hydrogen bonding present in H₂O molecules**
 - D. increasing boiling points with increasing molecular mass

Answer: C

Water has an abnormally high boiling point compared to the hydrides of other group 16 elements due to the presence of strong intermolecular hydrogen bonds, which require significant thermal energy to break.

18. Which one of the following is a common reaction of tin? (1)
- A. Sn(s) + H₂O(g) → SnO₂(s)
 - B. **✓ Sn(s) + dil. 2HCl(aq) → SnCl₂(aq) + H₂(g)**
 - C. Sn(s) + 2Cl₂(g) → SnCl₄(l) in cold media
 - D. Sn(s) + 2H₂O(g) → Sn(OH)₄(s)

Answer: B

Tin (Sn) reacts slowly with dilute hydrochloric acid to produce soluble tin(II) chloride and release hydrogen gas, which is a classic chemical property of moderately active metals.

19. A chemistry teacher has added different reactants and reagents in three different test tubes as described below: (1)
- I. Into the test tube A, he added ethanol, sodium dichromate, sulphuric acid. II. Into the test tube B, he added acetaldehyde, sodium borohydride and water. III. Into the tube C, he added methyl acetate and ethanol and sodium hydroxide. In which test tube would a reaction take place that provide acetic acid?
- A. I and II
B. III
C. ✓ I
D. II and III

Answer: C

In test tube I, ethanol is oxidized by the strong oxidizing agent sodium dichromate in acidic medium (H_2SO_4) to yield acetic acid. Acetaldehyde reduction in II yields ethanol, and ester hydrolysis in III under basic conditions yields sodium acetate, not free acetic acid.

20. One of the following examples of polymers is correctly matched with its uses (1)
- A. Polypropylene; electrical insulation
B. Polyethylene; food containers
C. Polytetrafluoroethylene; making shoes
D. ✓ **Polyvinyl chloride; making pipes**

Answer: D

Polyvinyl chloride (PVC) is chemically durable, rigid, and highly resistant to water and chemicals, making it the ideal polymer choice for fabricating water and sewage pipes.

21. Natural polymers are (1)
- A. polymers produced by condensation reaction of monomer units
B. polymers produced by the addition reaction of monomer units.
C. polymers produced by the substitution of one or more atoms in the monomer units.
D. ✓ **polymers found in some substances like rubber in nature.**

Answer: D

Natural polymers are those that occur naturally in plants and animals; natural rubber (harvested from rubber trees) is a prime example of a natural elastomer/polymer.

22. Oils are unsaturated fatty acids. The process of converting oils to solid fats involves (1)
- A. saponification with NaOH .
B. esterification of the acids.
C. halogenations of the C-C double bonds.
D. ✓ **hydrogenation of the C-C double bonds.**

Answer: D

Converting liquid vegetable oils (which are rich in unsaturated fatty acids with $\text{C}=\text{C}$ double bonds) into solid fats (saturated fats) is achieved through catalytic hydrogenation, which adds hydrogen across the double bonds.

23. The difference between colloids and suspension is that (1)
- A. most colloids and suspensions appear cloudy.
B. ✓ **colloidal particles are small enough and do not settle down unlike in a suspension.**
C. colloids are as transparent as solutions.
D. both colloids and suspensions are heterogeneous mixtures.

Answer: B

While suspension particles are large enough to settle out of the mixture over time under gravity, colloidal particles are small enough to remain permanently suspended due to Brownian motion.

24. The solubility of a substance is the amount of a substance that (1)
- A. dissolves more amount of solute than it can normally dissolve.
 - B. gives an unsaturated solution of substance at given temperature.
 - C. dissolves double the amount of solute than it can normally dissolve.
 - D. ✓ **gives a saturated solution of the substance at a given temperature.**

Answer: D

The solubility of a substance is defined as the maximum mass of solute that can dissolve in a given quantity of solvent at a specific temperature to yield a saturated solution in equilibrium with undissolved solute.

25. 50 mL of the supernatant saturated solution of NaCl was taken in an evaporating dish (weight= w_0) and evaporated over a Bunsen burner until all the water has evaporated and dry sodium chloride is left in the evaporating dish. The evaporating dish with the dry sodium chloride is weighed (weight= w_1). Given the following information, $w_0=47.5$ g and $w_1=66.2$. Calculate the solubility of NaCl in water assuming 50 mL of the solution is equal to 50 mL of the solvent (1)
- A. 113.7 g/100 g of water
 - B. ✓ **37.4 g/100 g of water**
 - C. 187 g/100 g of water
 - D. 18.7g/100 g of water

Answer: B

The mass of dry NaCl obtained is $w_1 - w_0 = 66.2$ g - 47.5 g = 18.7 g. Since 50 mL of solution is assumed to equal 50 g of solvent, the solubility is $(18.7 \text{ g} / 50 \text{ g of water}) * 100 = 37.4$ g of NaCl per 100 g of water.

26. One of the following given pairs represents examples of buffer systems (1)
- A. $\text{NH}_4\text{Cl}/\text{H}_2\text{O}$ and $\text{H}_2\text{O}/\text{CH}_3\text{COONa}$
 - B. NaOH/HCl and HNO_3/KOH
 - C. ✓ **$\text{NH}_4\text{OH}/\text{NH}_4\text{Cl}$ and $\text{CH}_3\text{COOH}/\text{CH}_3\text{COONa}$**
 - D. $\text{NH}_4\text{OH}/\text{CH}_3\text{COOH}$ and $\text{NH}_4\text{Cl}/\text{CH}_3\text{COONa}$

Answer: C

A buffer system consists of a weak acid and its conjugate base (like $\text{CH}_3\text{COOH}/\text{CH}_3\text{COONa}$) or a weak base and its conjugate acid (like $\text{NH}_4\text{OH}/\text{NH}_4\text{Cl}$).

27. The reaction between a weak acid and strong base as represented by the reaction between acetic acid and NaOH gives a basic solution because (1)
- A. ✓ **CH_3OO^- as a strong base picks up H^+ and causes excess OH^- ions.**
 - B. Na^+ is a strong acid and causes high concentration of H^+ .
 - C. CH_3COOH does not produce sufficient amount of H^+ ions.
 - D. The OH^- ions from NaOH are not completely neutralized.

Answer: A

The acetate ion (CH_3COO^-) is the conjugate base of a weak acid, meaning it is strong enough to react with water (hydrolyze) to produce hydroxide ions (OH^-), making the solution basic.

28. An acid is a substance that (1)
- A. produces more OH ions in water than H^+ ions.
 - B. has a bitter taste.
 - C. donates a pair of electrons to a chemical species.
 - D. ✓ **donates a proton in a chemical reaction.**

Answer: D

According to the Brønsted-Lowry definition, an acid is a proton (H^+) donor, while a base is a proton acceptor.

29. One of the following given mass of acids constitutes the corresponding equivalent of the acid (1)
- A. $\text{HCl} = 36.5 \text{ g} = 2 \text{ equivalents}$ B. ✓ $\text{H}_2\text{SO}_4 = 98 \text{ g} = 2 \text{ equivalent}$
- C. $\text{H}_3\text{PO}_4 = 98 \text{ g} = 2 \text{ equivalents}$ D. $\text{H}_2\text{SO}_4 = 49 \text{ g} = 4 \text{ equivalents}$

Answer: B

Since H_2SO_4 has two acidic protons (basicity = 2), its equivalent weight is half its molar mass ($98 \text{ g} / 2 = 49 \text{ g/equivalent}$). Therefore, 98 g of H_2SO_4 contains exactly 2 equivalents.

30. One of the following pairs shows Brønsted-Lowry acids behavior in water? (1)
- A. H_3O^+ and NH_3 B. HNO_3 and NO_3^-
- C. ✓ **HCl and NH_4^+** D. HPO_4^{2-} and PO_4^{3-}

Answer: C

Both HCl and NH_4^+ can act as Brønsted-Lowry acids in water because they have proton-donating capabilities, yielding Cl^- and NH_3 respectively.

31. Covalent compounds are liquids or gases at room temperature and have statements low melting and boiling points. Which of the following statements explains these properties of covalent compounds? (1)
- A. The unit of particles in covalent compounds are ions.
- B. The intermolecular forces of attraction in covalent compounds are strong.
- C. ✓ **Covalent compounds exist as separate molecules.**
- D. There are no forces of attraction between the molecules in covalent compounds.

Answer: C

Simple covalent compounds exist as discrete, separate molecules. The forces holding these molecules together (intermolecular forces) are relatively weak and easily overcome, resulting in low melting and boiling points.

32. Both carbonyl sulphide, COS (SCO), $\text{S}=\text{C}=\text{O}$ and carbon dioxide (CO_2) $\text{O}=\text{C}=\text{O}$ are linear molecules. COS is polar whereas CO_2 is non-polar. This is because (1)
- A. the $\text{C}=\text{O}$ bonds in both COS and CO_2 are polar.
- B. ✓ **CO_2 has a net dipole moment of zero.**
- C. sulphur is more electronegative than oxygen.
- D. regions of high negative charge is distributed equally around the central atom in COS .

Answer: B

Because CO_2 is completely linear and symmetric, the dipole moments of the two polar $\text{C}=\text{O}$ bonds are equal in magnitude and opposite in direction, cancelling each other out completely to give a net dipole moment of zero.

33. Which of the following statements is true about the formation of CH_4 according to valence bond theory? (1)
- A. ✓ **The 2s and three 2p orbitals in carbon hybridize to form four sp^3 orbitals.**
- B. The 2s and two 2p orbitals in carbon hybridize to form three sp^2 orbitals.
- C. Carbon can form two hybrid orbitals as it has got only two half-filled orbitals.
- D. The 2s and one 2p orbitals in carbon hybridize to form two sp orbitals.

Answer: A

In methane (CH_4), the carbon atom undergoes sp^3 hybridization, mixing its one 2s and three 2p orbitals to form four identical sp^3 hybrid orbitals directed toward the corners of a tetrahedron.

This is a duplicate of Question 42. High pressure and low temperature are thermodynamically favorable for maximizing the yield of NH_3 because the forward reaction is exothermic and results in a decrease in the number of moles of gas.

40. Which one of the following statements describes laboratory and industrial preparation of acetic respectively? (1)
- A. Reduction of ethanol by NaBH_4 and fermentation of propanol.
 - B. Reduction of toluene by KMnO_4 and reduction of ethanol by sodium dichromate.
 - C. ✓ **The oxidation of ethanol by sodium dichromate and fermentation of ethanol.**
 - D. Oxidation of toluene by KMnO_4 and fermentation of ethanol.

Answer: C

This is a duplicate of Question 43. Acetic acid is prepared in the lab by oxidation of ethanol with sodium dichromate and industrially by the biological fermentation of ethanol.

41. Which of the following is true about carboxylic acids? (1)
- A. Methanoic, Ethanoic and Citric acids are monocarboxylic acids.
 - B. ✓ **Carboxylic acid with the formation RCOOH .**
 - C. Citric acid is a typical dicarboxylic acid.
 - D. Propanedioic acid is the simplest dicarboxylic acid.

Answer: B

Carboxylic acids are characterized by the carboxyl functional group, represented by the general formula RCOOH (where 'formation' is a typographical error for 'formula' in the question).

42. What is the IUPAC name for the branched carboxylic acid: $\text{CH}_3\text{-CH}(\text{Cl})\text{-CH}(\text{CH}_3)\text{-CH}(\text{CH}_3)\text{-COOH}$ (1)
- A. 4-chloro-2, methyl 1-pentanoic acid
 - B. 1, 2-dimethyl-4-chloro 1-pentanoic acid
 - C. 4-chloro-1-methyl-1-pentanoic acid
 - D. ✓ **4-chloro-2, 3-dimethyl-1-pentanoic acid**

Answer: D

The longest continuous carbon chain containing the carboxyl group has 5 carbons (pentanoic acid), with the carbonyl carbon designated as C-1. Substituting substituents alphabetically, we have a chlorine at C-4 and methyl groups at C-2 and C-3, giving 4-chloro-2,3-dimethyl-1-pentanoic acid.

43. Esters are characterized by the following properties EXCEPT (1)
- A. esters have lower boiling point compared to the carboxylic acid alcohols
 - B. esters have pleasant odors of perfumes and food flavoring
 - C. ✓ **esters have higher boiling point than carboxylic acid and alcohol**
 - D. all esters are soluble in inorganic solvents and organic

Answer: C

Esters lack hydrogen-bonding hydrogen atoms, meaning their intermolecular forces are weaker than those of carboxylic acids and alcohols. Consequently, they have lower boiling points, making Option C the false statement.

44. The sanitizer in wide use for protection against Covid-19 is labelled 83% alcohol. How can one scientifically check the concentration? (1)
- A. ✓ **experimentation**
 - B. forming hypothesis
 - C. making observation
 - D. collection of data

Answer: A

To scientifically verify the concentration of a substance like alcohol in a solution, one must perform laboratory experimentation, such as density measurements, distillation, or gas chromatography.

45. According to Hund's rule equal energy (degenerate) orbitals are filled with (1)
- A. ✓ **maximum number of unpaired electrons with parallel spins**
 - B. two electrons of opposite spins placed in the first orbitals
 - C. maximum number of unpaired electrons with opposite spins
 - D. two electrons of parallel spins placed in the first orbital

Answer: A

Hund's rule of maximum multiplicity states that for a given electron configuration, degenerate orbitals are singly occupied as far as possible with parallel spins to minimize electron-electron repulsion.

46. In the modern periodic table (1)
- A. elements with similar properties are placed in the same period
 - B. ✓ **non-metals are placed on the right side of the periodic table**
 - C. transition and inner-transition elements are placed in the middle of the periodic table
 - D. metals are placed on the right hand side of the periodic table

Answer: B

In the modern periodic table, non-metals are positioned on the upper-right side, while metals occupy the left, center, and bottom areas.

47. The electrolysis of liquid (molten) NaCl in the set-up for the electrochemical cell is given in the following figure (1)
below. Which of the following statements is true about the electrolysis of molten sodium chloride?
- A. Na is oxidized at the anode
 - B. Cl₂ is formed at the cathode
 - C. O₂ is produced at the anode due to the oxidation of water
 - D. ✓ **The net reaction produces Cl₂ at the anode and Na at the cathode.**

Answer: D

During the electrolysis of molten sodium chloride, chloride ions are oxidized to chlorine gas at the anode, and sodium ions are reduced to sodium metal at the cathode.

48. In the reaction mixture of two species NH₄OH and NH₄Cl, which one of the following is true about the reaction mixture? (1)
- A. ✓ **The presence of NH₄⁺ ion suppresses the dissociation of the weak base NH₄OH.**
 - B. The NH₄⁺ ion is a spectator ion in the reaction mixture.
 - C. The reaction equilibrium is shifted towards the right due to the presence of NH₄⁺ ions.
 - D. The presence of NH₄⁺ in the reaction mixture makes the solution more basic.

Answer: A

According to the common-ion effect, adding ammonium ions (from the strong electrolyte NH₄Cl) shifts the dissociation equilibrium of the weak base NH₄OH to the left, suppressing its dissociation.

49. Which one of the following is correct about K_w at different temperature? The ionic product of water K_w equals (1)
 $K_w = 1.0 \times 10^{-14}$ at 25°C $K_w = 2.92 \times 10^{-14}$ at 40°C $\sqrt{K_w} = 1 \times 10^{-7}$ $\sqrt{K_w} = 1 \times 10^{-7}$
- A. At 40°C pure water is no more neutral
- B. ✓ **Water dissociates to a higher extent at 40°C than at 25°C .**
- C. Hydroxyl ion concentration is higher at 40°C than hydrogen ion concentration
- D. Hydrogen ion concentration at 25°C is higher than at 40°C .

Answer: B

Since the autoionization constant of water (K_w) increases from 1.0×10^{-14} at 25°C to 2.92×10^{-14} at 40°C , water dissociates to a greater extent at the higher temperature.

50. What is reduction? Reduction is (1)
- A. loss of electrons and decrease in oxidation number
- B. gain of electrons and increase in oxidation number
- C. gain of electrons and no change in oxidation number
- D. ✓ **gain of electrons and decrease in oxidation number**

Answer: D

Reduction is defined as the gain of electrons by a chemical species, which results in a decrease in its oxidation number.

51. During the electrolysis of dilute aqueous sulphuric acid, the ions present in solution are H^+ , OH^- and SO_4^{2-} . (1)
 Which ions are preferentially discharged at the cathode and anode, respectively?
- A. Anode = $\text{SO}_4^{2-}(\text{aq}) + 4\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{SO}_2(\text{g}) + 2\text{H}_2\text{O}$, Cathode = $2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g})$
- B. Anode = $4\text{OH}(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g}) + 4\text{e}^-$, Cathode = $2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g})$
- C. ✓ **Anode = $2\text{H}_2\text{O}(\text{l}) \rightarrow \text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^-$, Cathode = $2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g})$**
- D. Anode = $4\text{OH}(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g}) + 4\text{e}^-$, Cathode = $2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$

Answer: C

In dilute sulfuric acid, water is oxidized at the anode to produce oxygen gas and hydrogen ions, while hydrogen ions are reduced at the cathode to produce hydrogen gas.

52. Which one of the following is NOT correct about electrodes and electrochemical cells? (1)
- A. The overall cell potential is calculated by the formula $E^\circ_{\text{cell}} = E_{\text{Cathode}} - E_{\text{Anode}}$
- B. Electrons flow spontaneously from negative to positive electrodes
- C. The difference in the electrical potential of the electrode is positive that is positive cell
- D. ✓ **E°_{cell} is greater than zero for non-spontaneous process**

Answer: D

For any spontaneous process under standard conditions, the standard cell potential (E°_{cell}) must be greater than zero, meaning E°_{cell} is less than zero for a non-spontaneous process.

53. Which one of the following is NOT correct about electrodes and electrochemical cells? (1)
- A. The overall cell potential is calculated by the formula $E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$
- B. Electrons flow spontaneously from negative to positive electrodes.
- C. The difference in the electrical potential of the electrode is positive that is positive cell.
- D. ✓ **E°_{cell} is greater than zero for non-spontaneous process.**

Answer: D

A positive standard cell potential ($E^\circ_{\text{cell}} > 0$) indicates a spontaneous reaction, so E°_{cell} is negative (less than zero) for non-spontaneous processes.

54. The "like dissolves like" rule accounts for one of the following observation (1)
- A. The solubility of C_2H_6 in H_2O .
B. ✓ **The solubility of C_6H_6 in CCl_4 .**
C. The insolubility of I_2 in H_2O .
D. The solubility of KBr in C_7H_8 .

Answer: B

The 'like dissolves like' rule states that substances with similar intermolecular forces are soluble in each other; both benzene (C_6H_6) and carbon tetrachloride (CCl_4) are non-polar, making them highly miscible.

55. The concentrated sulphuric acid H_2SO_4 we use in the laboratory is 98% H_2SO_4 by mass and has a density of 1.83 g/mL. Below are given the concentrations of the acid in various units, which of the given alternatives correctly describes the concentration of the acid? (1)
- A. Molarity 36.6 M, Normality 18.3 N, Mole fraction 0.1
B. ✓ **Molarity 18.3 M, Normality 36.6 N, Mole fraction 0.9**
C. Molarity 1.83 M, Normality 3.66 N, Mole fraction 0.9
D. Molarity 18.3 M, Normality 3.66 N, Mole fraction 0.9

Answer: B

A 98% H_2SO_4 solution with a density of 1.83 g/mL has a molarity of 18.3 M, a normality of 36.6 N (since H_2SO_4 is diprotic), and a mole fraction of approximately 0.9.

56. In the electrolysis of copper sulphate solution using graphite electrodes, O_2 is liberated at the anode and copper metal is deposited at the cathode. If the electrolysis of $CuSO_4$ is performed using copper electrode, what happens at the anode and cathode? (1)
- A. At the anode H_2 is liberated, whereas copper is deposited at the cathode.
B. ✓ **At the anode the copper electrode dissolves and copper metal is deposited at the cathode.**
C. No electrochemical reaction takes place involving copper.
D. At the anode copper is reduced, whereas copper is oxidized at the cathode.

Answer: B

When active copper electrodes are used, copper metal at the anode is preferentially oxidized and dissolves as Cu^{2+} , while Cu^{2+} ions in solution are reduced and deposited as copper metal at the cathode.

57. The statement 'the amount of a substance consumed or of produced in an electrolytic cell is directly proportional to the amount of electricity that passes through the cell' is known as (1)
- A. Raoult's law.
B. Dalton's law.
C. Henry's law.
D. ✓ **Faraday's law.**

Answer: D

This statement is the definition of Faraday's first law of electrolysis, which relates the chemical change in an electrochemical cell directly to the quantity of electricity passed.

58. Given the following electromotive series of selected metals with their standard reduction potentials Which of the following statements is correct about reactivity of the metals? (1)
- A. ✓ **K is the strongest reduction agent among the metal silver.**
B. Cu is the strongest reducing agent in the group.
C. Pb is more easily oxidized than Al.
D. The reaction $Cu + Zn^{2+} \rightleftharpoons Cu^{2+} + Zn$ is spontaneous.
E. Al is the most reactive metal in the series.

Answer: A

Potassium (K) has a highly negative standard reduction potential, which means it is extremely easy to oxidize and acts as the strongest reducing agent in the series.

59. One of the following is NOT true about the effects of corrosion?

(1)

- A. It causes enormous damage to buildings, bridges, ships and cars.
- B. It causes deterioration of metals by spontaneous chemical process.
- C. ✓ **Corrosion forms protection oxide layers to prevent damage.**
- D. Damage from corrosion costs billions of dollars annually.

Answer: C

While some metals like aluminum form protective oxide layers, corrosion (especially rusting of iron) is generally a destructive process that causes deterioration and does not protect the metal.

60. Which statement is true about catalysts?

(1)

- A. A positive catalyst decreases the rate of a reaction by increasing the activation energy.
- B. A catalyst slows down or speeds up a reaction, itself being consumed.
- C. ✓ **The role of a catalyst is to increase or decrease the rate of a reaction by lowering or increasing the activation energy.**
- D. A negative catalyst increases the rate of a reaction by decreasing the value of activation energy.

Answer: C

A catalyst provides an alternative reaction pathway with a different activation energy, thereby increasing (positive catalyst) or decreasing (negative catalyst) the reaction rate without being consumed.

61. According to the transition state theory

(1)

- A. ✓ **in the activated complex, the original bonds are weakened and the new bonds are partially formed.**
- B. the collision between two reacting species results in the formation of an activated complex, which has less energy than both the reactants and products.
- C. the standard reaction enthalpy (ΔH°) depends on the magnitude of the activation energy (E_a).
- D. the activation energy is the energy that must be absorbed or released by reactants to reach the activated complex.

Answer: A

According to transition state theory, collision of reactants forms an unstable, high-energy activated complex in which original reactant bonds are partially broken and new product bonds are partially formed.

62. Which of the following is true about the rate constant?

(1)

- A. ✓ **The value of a rate constant tells us how fast or slow a reaction is.**
- B. It expresses the relationship between the rate of a chemical reaction and the volume of reacting species.
- C. A small rate constant indicates a faster reaction and a larger rate indicates a slower reaction.
- D. The value of a rate constant is independent of reaction conditions.

Answer: A

The rate constant (k) is a proportionality constant in the rate law that quantifies the speed of a chemical reaction, where a larger k corresponds to a faster reaction rate.

63. The mathematical expression $\log k = (-E_a / 2.303R)1/T + \log A$ derived from the Arrhenius equation is of important as it shows (1)

- A. **for a given value of activation energy the value of the rate constant increases as the temperature increases.**
- B. reactions with larger activation energies have higher values of k and are therefore faster.
- C. for a given value of activation energy, the value of the rate constant decreases as the temperature increases.
- D. reactions with larger activation energies, the value of the rate constant decreases as the temperature increases.

Answer: A

In the Arrhenius equation, because the exponent contains temperature in the denominator with a negative sign, the rate constant (k) increases exponentially as the temperature increases.

64. Which of the following is true about isotopes? Isotopes of an element have (1)

- A. **different number of neutrons and same number of protons.**
- B. the same number of electrons and neutrons.
- C. the same atomic mass but different atomic numbers.
- D. different physical and chemical properties.

Answer: A

Isotopes are atoms of the same chemical element that contain the identical number of protons (same atomic number) but different numbers of neutrons (different mass numbers).

65. For a first order reaction, the concentration versus time of the reaction mixture is given by the following graph If a is the initial concentration of the reactant and if the half-life is the 1hr, after how many hours would be the concentration of reactant produced to $a/32$? (1)

- A. 4hr
- B. 1hr
- C. 3hr
- D. **5hr**

Answer: D

A concentration reduced to $a/32$ (which is $1/2^5$ of the initial amount) requires 5 half-lives. Since the half-life is 1 hour, the total time required is 5 hours.

66. Silver ($Z=47$) has several known isotopes, but two occur naturally, ^{107}Ag and ^{109}Ag . Given the following mass spectrometric data, calculate the atomic mass of Ag (1)

- A. 107.94 amu
- B. 108.9 amu
- C. **107.86 amu**
- D. 107.4 amu

Answer: C

Even though the specific mass spectrometric data is omitted in the question text, the average atomic mass of silver (Ag) is a well-known chemical constant (~ 107.87 amu), which is closest to the value of 107.86 amu given in option C.

67. Which statement correctly describes Heisenberg's uncertainty principle? (1)

- A. A particle with a mass moving at a given speed can be described by the wave characteristic of material particles.
- B. If we measure the momentum of a particle precisely then its position will be correspondingly precise.
- C. **Both the location and the momentum of a subatomic particle like the electron cannot be precisely known.**
- D. A small particle like the reaction can behave both as a particle and a wave.

Answer: C

Heisenberg's uncertainty principle states that it is fundamentally impossible to simultaneously determine both the exact position and momentum of a subatomic particle like an electron with absolute precision.

68. According to the Lewis definition of an acid, an acid is a substance that

(1)

- A. accepts a H⁺ ion.
- B. dissociates in water to yield H₃O⁺.
- C. ✓ **accepts a pair of electrons.**
- D. donates an OH⁻ ion.

Answer: C

According to the Lewis theory of acids and bases, a Lewis acid is defined as an electron-pair acceptor, while a Lewis base is an electron-pair donor.

69. Water is a weak electrolyte because

(1)

- A. it can accept a proton from an acid and donate a proton to a base.
- B. it has a very high ionic product, K_w .
- C. it acts both as Bronsted-Lowry and base.
- D. ✓ **it undergoes a reversible dissociation with a very low ionic product, K_w .**

Answer: D

Water is a weak electrolyte because it self-ionizes to a very small extent. This reversible dissociation is represented by a very low ion-product constant ($K_w = 1.0 \times 10^{-14}$ at 25 °C), meaning only a minute fraction of molecules dissociate into ions.

— END OF MARKING KEY —