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Chemistry, 2015 EC, natural science, entrance exam

Grade 12 · Chemistry · 2015 E.C.

MARKING KEY — CONFIDENTIAL

Time allowed: 120 minutes | **Questions:** 76 | **Total marks:** 76

1. Which one of the following IS TRUE about isotopes? (1)

A. Isotopes of an element are atoms that have different number of electrons and protons.

B. Isotopes of an element are identical in mass number.

C. Isotopes of the same elements contain the same number of neutrons.

D. ✓ **Isotopes of an element have the same chemical properties.**

Answer: D

Isotopes are atoms of the same element with the same number of protons and electrons but a different number of neutrons. Because chemical behaviour is decided by the electron arrangement, all isotopes of an element react the same way, so D is true.

A is wrong because the proton and electron counts are the same. B is wrong because the mass numbers differ. C is wrong because it is the neutron count that changes.

Textbook: Chemistry Grade 9, Unit 3 Structure of the Atom, section 3.5 Composition of an Atom and the Isotopes (page 87).

2. Which one of the following describes the quantum mechanical model? (1)

A. ✓ **The locations of electrons in an atom are described in terms of probability.**

B. An atom is represented by a solid indestructible sphere.

C. An atom is a sphere with a positively charged matter, in which electrons are embedded.

D. Electrons moved around the nucleus of an atom in circular orbits.

Answer: A

In the quantum mechanical model we cannot say exactly where an electron is. We can only give the probability of finding it in a region of space called an orbital, so A is correct.

B is Dalton's solid sphere model, C is Thomson's plum pudding model, and D is Bohr's model with fixed circular orbits.

Textbook: Chemistry Grade 11, Unit 1 Atomic Structure and Periodic Properties of the Elements, section 1.6 The Quantum Mechanical Model of the Atom (page 34).

3. Which one of the following is the diagrammatic representation of ^{35}Cl? (1)

A. Diagram A

B. Diagram B

C. ✓ **Diagram C**

D. Diagram D

Answer: C

For chlorine-35 the atomic number is 17 and the mass number is 35. The correct diagram must show 17 protons and 18 neutrons in the nucleus (35 minus 17 = 18) and 17 electrons arranged in shells as 2, 8, 7.

Any diagram with a different proton, neutron or electron count is wrong. The recorded answer is diagram C.

Textbook: Chemistry Grade 9, Unit 3 Structure of the Atom, section 3.5 Composition of an Atom and the Isotopes (page 87).

4. Which one of the following is an ionic compound? (1)

A. ✓ **$CaCl_2$** **B.** CO_2

C. PCl_3 **D.** H_2O_2

> **Answer:** A
> CaCl2 is made of a metal (calcium) and a non-metal (chlorine). Calcium gives away its two valence electrons to two chlorine atoms, forming Ca2+ and Cl- ions held together by electrostatic attraction. That is an ionic compound.
> CO2, PCl3 and H2O2 are each built from non-metal atoms only, which share electrons, so they are covalent compounds.
> **Textbook:** Chemistry Grade 9, Unit 5 Chemical Bonding, section 5.2 Ionic Bonding (page 146).

5. An element is located in Group VIIA and 3rd period of the modern periodic table. On the basis of this the element: (1)

A. generally forms an ion with -2 charges. **B.** has very low ionization energy.

C. ✓ **forms an acidic oxide.** **D.** has extremely low electron affinity.

> **Answer:** C
> Group VIIA, period 3 is chlorine, a halogen and a reactive non-metal. Non-metal oxides are acidic, and chlorine forms acidic oxides such as Cl2O7, which gives HClO4 in water. So C is correct.
> A is wrong because a halogen gains one electron and forms a 1- ion, not 2-. B and D are wrong because halogens have high ionization energy and high electron affinity.
> **Textbook:** Chemistry Grade 9, Unit 4 Periodic Classification of Elements, section 4.4 The Major Trends in the Periodic Table (page 128).

6. Which of the properties of solvents WOULD NOT be affected by the formation of a solution with a non-volatile solute? (1)

A. Boiling Point **B.** Chemical potential

C. ✓ **Chemical identity** **D.** Freezing Point

> **Answer:** C
> Dissolving a non-volatile solute changes the solvent's physical properties: the vapor pressure and chemical potential fall, the boiling point rises and the freezing point drops.
> Dissolving is a physical process, so the solvent molecules themselves are unchanged. The chemical identity of the solvent stays the same, which makes C the property that is not affected.

7. The partial pressure of acetylene, C_2H_2, in a container is 10 atm at 25°C. What is the solubility in molarity of C_2H_2, assume that C_2H_2 obeys Henry's law? (KH = 1.04 mol/L atm) (1)

A. 9.62 **B.** 0.104

C. 104 **D.** ✓ **10.4**

> **Answer:** D
> Henry's law says the solubility of a gas is proportional to its partial pressure: $S = K_H \times P$.
> Substitute the values: $S = 1.04 \times 10 = 10.4$ mol/L. So the solubility is 10.4 M, answer D.
> Option B (0.104) comes from wrongly dividing by the pressure instead of multiplying.
> **Textbook:** Chemistry Grade 10, Unit 2 Solutions, section 2.3 Solubility as an Equilibrium Process (page 74).

8. What is the normality of a solution that contains 19.6 g of H_2SO_4 in 20 mL of the solution? (1)

A. 0.02
B. 0.01
C. ✓ **20**
D. 10

> **Answer:** C
> Normality is the number of equivalents of solute per liter of solution. One mole of H2SO4 gives 2 H+ ions, so its equivalent mass is $98 \div 2 = 49$ g.
> Equivalents: $19.6 \div 49 = 0.4$ eq. Volume: 20 mL = 0.02 L. Normality: $0.4 \div 0.02 = 20$ N, answer C.
> The tempting answer 10 is only the molarity (0.2 mol in 0.02 L). For H2SO4 the normality is twice the molarity.
> **Textbook:** Chemistry Grade 12, Unit 1 Acid-Base Equilibria, section 1.5.2 Equivalents of Acids and Bases.

9. Which one of the following illustrates an extensive property? (1)

A. The electrode potential at standard condition for the half-reaction $2Cu^{2+} + 4e^- \rightarrow 2Cu$ is the same as for $Cu^{2+} + 2e^- \rightarrow Cu$.
B. ✓ **If a system is divided into parts and it is found that the property of the complete system has a value that is the sum of the values of the property of all the parts.**
C. Doubling the volume of a sample also doubles the mass; so the ratio of mass to volume remains the same.
D. If water in two beakers at the same temperature are mixed to make a single quantity and the temperature of the combined quantity of water is the same as it was in the two separate beakers.

> **Answer:** B
> An extensive property depends on the amount of matter present, so its value for a whole system equals the sum of the values of its parts. That is exactly what B describes. Mass and volume are common examples.
> A, C and D all describe intensive properties: electrode potential, density (the mass to volume ratio) and temperature do not change with the amount of substance.
> **Textbook:** Chemistry Grade 9, Unit 2 Measurements and Scientific Methods, section 2.2 Chemistry as Experimental Science.

10. The point in a titration at which the number of moles of OH^- ions added to a solution is equal to the number of moles of H^+ ions originally present is: (1)

A. Zero point
B. End point
C. Triple point
D. ✓ **Equivalence point**

> **Answer:** D
> The equivalence point of a titration is the point where the moles of added OH- exactly equal the moles of H+ that were in the flask, so the acid is completely neutralized. That is the definition given, answer D.
> The end point is different: it is the point where the indicator changes color, which is only an estimate of the equivalence point.
> **Textbook:** Chemistry Grade 12, Unit 1 Acid-Base Equilibria, section 1.5.3 Acid-Base Titrations.

11. Which one of the following is TRUE about the electrolysis of a molten hypothetical electrolyte, MX? (1)

A. X is produced at the negative electrode.

B. M is produced at the anode.

C. Electrons are not transferred from one species to the other.

D. ✓ **The overall reaction is redox reaction.**

> **Answer:** D
> In the electrolysis of molten MX, the cation M+ gains electrons at the cathode and the anion X- loses electrons at the anode. Since electrons are lost by one species and gained by another, the overall change is a redox reaction, so D is true.
>
> A and B swap the electrodes: the metal forms at the negative electrode (cathode) and X forms at the anode. C is wrong because electron transfer is exactly what happens.
>
> **Textbook:** Chemistry Grade 10, Unit 4 Energy Changes and Electrochemistry, section 4.4 Electrolysis (page 190).

12. During the extraction of an unknown metal, the metallic ore was fused with NaOH in air and then dissolved in water to obtain the soluble unknown metal containing species. Reduction with carbon is followed after the solution is treated with HCl. Finally the obtained oxide is reduced to its metallic form by aluminum. The most probable unknown metal would be: (1)

A. Ca

B. Zn

C. ✓ **Cr**

D. Pb

> **Answer:** C
> The clues match the extraction of chromium from chromite ore. Fusing the ore with NaOH in air oxidizes the chromium to a soluble chromate, which dissolves in water. Treating with acid converts it toward dichromate, reduction with carbon gives the oxide Cr2O3, and finally aluminium reduces the oxide to chromium metal (the aluminothermic process).
>
> Calcium is obtained by electrolysis of its molten chloride, and zinc and lead are obtained by roasting their sulfide ores, so those routes do not fit the description.

13. Why tin does NOT react with cold water but calcium reacts with cold water quite readily? (1)

A. ✓ **Due to its less reactive nature.**

B. Due to the formation of a thin oxide layer.

C. Due to its physical state.

D. Due to the pH of water.

> **Answer:** A
> How a metal behaves with water follows its position in the activity series. Calcium is high in the series, so it displaces hydrogen from cold water. Tin is far less reactive and cannot do this, so A is the reason.
>
> B describes metals like aluminium, whose protective oxide layer stops further reaction; that is not why tin stays quiet in cold water.
>
> **Textbook:** Chemistry Grade 12, Unit 2 Electrochemistry (the metal activity series).

14. Why is vulcanization performed in natural rubber? (1)

A. To convert the monomer unit in natural rubber in to polymer.

B. ✓ **To establish cross-links between polymer chain in the natural rubber.**

C. To decrease the number of monomer unit in the natural rubber.

D. To increase the number of monomer unit in the natural rubber.

> **Answer:** B
> Natural rubber is made of long polymer chains that slide past each other, so it is soft and sticky. Vulcanization heats the rubber with sulfur, and the sulfur atoms form cross-links that tie neighbouring chains together. The cross-linked rubber is stronger, harder and more elastic, so B is correct.
>
> Vulcanization does not add or remove monomer units and it does not polymerize anything; the chains already exist.
>
> **Textbook:** Chemistry Grade 12, Unit 4 Polymers, section 4.3 Classification of Polymers.

15. Which one of the following explains the determination of the cell potential of Zn-Cu cell using voltmeter? (1)

A. In the Cu half-cell, Cu metal will be dipped in $ZnSO_4$ solution.

B. In the Zn half-cell, Zn metal will be dipped in $CuSO_4$ solution.

C. ✓ **Each U-tube served as a salt bridge that can be filled with saturated KCl.**

D. After the experiment the mass of zinc is increased.

> **Answer:** C
> In a Zn-Cu (Daniell) cell, each metal stands in a solution of its own ions: Zn in ZnSO4 and Cu in CuSO4. The two half-cells are joined by a salt bridge, often a U-tube filled with a saturated KCl solution, which keeps both solutions electrically neutral. So C is the correct description.
>
> A and B put each metal in the wrong solution. D is wrong because the zinc electrode is the anode and loses mass while the cell runs.
>
> **Textbook:** Chemistry Grade 10, Unit 4 Energy Changes and Electrochemistry, section 4.3 Electrochemical Cells (page 184).

16. Which one of the following is an example of molecular crystals? (1)

A. Diamond

B. Sodium Chloride

C. ✓ **Solid carbon dioxide**

D. Magnesium

> **Answer:** C
> A molecular crystal is built from whole molecules held in place by weak intermolecular forces. Solid carbon dioxide (dry ice) is CO2 molecules packed together, so it is a molecular crystal. It is soft and passes straight to gas at a low temperature.
>
> Diamond is a covalent network solid, sodium chloride is an ionic crystal, and magnesium is a metallic crystal.
>
> **Textbook:** Chemistry Grade 11, Unit 2 Chemical Bonding, section 2.6 Types of Crystal (page 135).

17. Which one of the following COULD NOT be considered as factor influencing the rate of chemical reaction? (1)

A. Presence of catalyst

B. Surface area of reactants

C. ✓ **The rate constant of the reaction**

D. Temperature of reactants

> **Answer:** C
> The factors that influence reaction rate are the nature of the reactants, their concentration, temperature, surface area and the presence of a catalyst. Changing any of these changes how fast the reaction goes.
>
> The rate constant k is not a factor you can adjust from outside. It is a value that appears in the rate law and simply reflects the reaction and the temperature, so C is the odd one out.
>
> **Textbook:** Chemistry Grade 11, Unit 4 Chemical Kinetics, section 4.3 Factors Affecting the Rate of a Chemical Reaction (page 207).

18. Which one of the following shows the hybridization scheme of the central atom in H_2O? (1)

A. Diagram A
B. Diagram B
C. ✓ **Diagram C**
D. Diagram D

> **Answer:** C
> The oxygen atom in H2O is sp3 hybridized. Its one 2s orbital and three 2p orbitals mix to give four sp3 hybrid orbitals. Two of them hold the two lone pairs, and the other two overlap with the hydrogen 1s orbitals to form the two O-H bonds.
> The correct diagram must therefore show four sp3 orbitals on oxygen, two filled with lone pairs and two used for bonding. The recorded answer is diagram C.
> **Textbook:** Chemistry Grade 11, Unit 2 Chemical Bonding, section 2.5.1 Valence Bond (VB) Theory (page 115).

19. In which of the following order of a reaction, a plot of ln [A]t versus time is a straight line whose slope is -k? (1)

A. ✓ **First**
B. Zero
C. Third
D. Second

> **Answer:** A
> For a first order reaction the integrated rate law is $\ln[A]_t = -kt + \ln[A]_0$. This has the form of a straight line: plotting ln[A] against time gives a line with slope equal to minus k. So the answer is first order.
> For zero order the straight-line plot is [A] against time, and for second order it is 1/[A] against time.
> **Textbook:** Chemistry Grade 11, Unit 4 Chemical Kinetics, section 4.2 The Rate of a Reaction (page 193).

20. A forward and reverse reaction continues to take place at equal rate in microscopic level without change in composition at macroscopic level. This statement is the definition of: (1)

A. Chemical kinetics
B. ✓ **Dynamic equilibrium**
C. Degree of freedom
D. The law of mass action

> **Answer:** B
> At dynamic equilibrium the forward and reverse reactions have not stopped. They keep running at equal rates, so molecules keep changing at the microscopic level while the overall amounts stay constant at the macroscopic level. That is exactly the statement given, so B is correct.
> **Textbook:** Chemistry Grade 11, Unit 5 Chemical Equilibrium, section 5.2.2 Attainment and Characteristics of Chemical Equilibria (page 225).

21. The heat change at constant pressure that results when 1 mole of a compound is formed from its elements in their standard states is: (1)

A. standard entropy of reaction
B. standard enthalpy of reaction
C. standard reduction potential
D. ✓ **standard enthalpy of formation**

> **Answer:** D
> The standard enthalpy of formation is the heat change at constant pressure when one mole of a compound is formed from its elements, each in its standard state. The question repeats this definition word for word, so D is correct.
> The standard enthalpy of reaction (option B) is more general: it refers to any reaction as written, not to forming one mole of a compound from its elements.

22. What is a redox reaction? It is a reaction in which: (1)

A. two insoluble ions in compounds form an insoluble products.

B. ✓ **electrons are transferred between species.**

C. atoms or ions of two compound exchange bonding partners.

D. an acid and a base neutralize each other.

Answer: B

A redox reaction is a reaction in which electrons are transferred from one species to another. One species is oxidized (loses electrons) and the other is reduced (gains electrons), so B is correct.

A describes precipitation, C describes a double displacement (exchange) reaction, and D describes neutralization.

Textbook: Chemistry Grade 10, Unit 1 Chemical Reactions and Stoichiometry, section 1.4 Oxidation and Reduction Reactions (page 20).

23. Which one of the following explains how electroplating takes place? (1)

A. The electrolyte is an aqueous solution of a salt of the plated metal.

B. The object to be electroplated either metal or graphite-coated plastic constitutes the anode.

C. ✓ **The cations in the electrolyte are supplied either by the added salt or from oxidation of the anode.**

D. Metal is deposited on the anode by reduction of ions in the electrolyte solution.

Answer: C

In electroplating, the object to be coated is the cathode and the plating metal is usually the anode, dipped in a solution of that metal's salt. The metal ions that get deposited come from the dissolved salt, and they are replaced as the anode metal oxidizes and dissolves. That is what C says.

B is wrong because the object is the cathode, not the anode. D is wrong because deposition by reduction happens at the cathode.

Textbook: Chemistry Grade 12, Unit 2 Electrochemistry, section 2.4 Industrial Application of Electrolysis (Electroplating of Metals).

24. How does the equivalent mass of a base is obtained? (1)

A. By multiplying its molar mass by the number of OH^- ions furnished by one formula unit of a base.

B. ✓ **By dividing its molar mass by the number of OH^- ions furnished by one formula unit of a base.**

C. By multiplying its number of equivalent to the number of OH^- ions furnished by one formula unit of a base.

D. By dividing its number of equivalent by the number of OH^- ions furnished by one formula unit of a base.

Answer: B

The equivalent mass of a base is its molar mass divided by the number of OH- ions that one formula unit supplies. For example, Ca(OH)2 gives 2 OH-, so its equivalent mass is 74 divided by 2, which is 37 g. So B is correct.

Multiplying instead of dividing (option A) would make bases that give more OH- look heavier per equivalent, which is the opposite of the definition.

Textbook: Chemistry Grade 12, Unit 1 Acid-Base Equilibria, section 1.5.2 Equivalents of Acids and Bases.

25. Which one of the following reactions would occur spontaneously in an aqueous solution at 25°C? Assume that the initial concentrations of the dissolved species are all 1.0 M. (1)

A. $2Ag(s) + Ni^{2+}(aq) \rightarrow 2Ag^{+}(aq) + Ni(s)$

B. $2Br^{-}(aq) + Sn^{2+}(aq) \rightarrow Br_2(l) + Sn(s)$

C. $Cu^{+}(aq) + Fe^{2+}(aq) \rightarrow Cu(s) + Fe^{3+}(aq)$

D. ✓ **$Ca(s) + Cd^{2+}(aq) \rightarrow Ca^{2+}(aq) + Cd(s)$**

Answer: D

A redox reaction is spontaneous when the stronger reducing agent gives electrons to the stronger oxidizing agent, that is, when the cell potential is positive. Calcium is a very active metal (standard potential about -2.87 V), while Cd2+/Cd is much higher (about -0.40 V), so Ca readily reduces Cd2+. The cell potential is positive and D is spontaneous.

In A, B and C the electrons would have to flow from a weaker reducing agent to a weaker oxidizing agent, giving a negative cell potential, so those reactions do not occur on their own.

Textbook: Chemistry Grade 12, Unit 2 Electrochemistry, section 2.5 Voltaic Cells.

26. Which of the following statements describes chemical industries? It is: (1)

A. an area of chemistry concerned with the speeds, or rates, at which chemical reactions occur.

B. an expression for the chemical composition of a compound in terms of the symbols of the atoms of the elements involved.

C. a process in which dissolved solute comes out of solution and forms crystals.

D. ✓ **a firm that involves usage of raw material to produce desired products by using chemical reactions and refining methods.**

Answer: D

A chemical industry is a firm or plant that takes raw materials and turns them into useful products using chemical reactions and refining steps, so D is the right description.

A defines chemical kinetics, B defines a chemical formula, and C defines crystallization.

Textbook: Chemistry Grade 12, Unit 3 Industrial Chemistry, section 3.2 Natural Resources and Industry.

27. What will be the product if phosphorus reacts with excess amount of oxygen? (1)

A. H_3PO_3

B. H_3PO_4

C. ✓ **P_4O_{10}**

D. P_4O_6

Answer: C

Phosphorus burns in oxygen to form oxides. With excess oxygen the higher oxide forms: P4 + 5O2 gives P4O10 (tetraphosphorus decoxide). So C is correct.

P4O6 forms only when the oxygen supply is limited. H3PO3 and H3PO4 are acids produced later, when the oxides react with water, not direct products of burning phosphorus.

28. One of the basic differences between metallic conduction and electrolytic conduction is: (1)

A. ✓ **The conduction of electricity is due to the movement of ions in an electrolytic conduction while the flow of mobile electrons in metallic conduction.**

B. The charge carriers in metals are cations and anions while mobile electrons are in electrolytic conduction.

C. The charge carriers in metals are localized electrons while strongly held ions are in electrolytic conduction.

D. The conduction of electricity is due to the movement of ions in metallic conduction while the flow of mobile electrons in electrolytic conduction.

Answer: A

In a metal, current is carried by delocalized (mobile) electrons drifting through the fixed lattice of metal ions. In an electrolyte, current is carried by the movement of positive and negative ions toward the electrodes. Option A states this difference correctly.

B, C and D all swap or misname the charge carriers.

Textbook: Chemistry Grade 12, Unit 2 Electrochemistry, section 2.2 Electrolysis of Aqueous Solutions (metallic and electrolytic conduction).

29. Which one of the following gases is released from combustion of a fuel in an industrial machinery causing global warming? (1)

A. CO
B. ✓ **CO_2**
C. NO
D. SO_2

> **Answer:** B
> Burning any carbon-based fuel releases carbon dioxide. CO2 is the main greenhouse gas: it traps heat radiated from the Earth's surface and drives global warming, so B is correct.
> CO is a toxic gas, and NO and SO2 are mainly linked to acid rain and smog rather than to global warming.
> **Textbook:** Chemistry Grade 12, Unit 5 Introduction to Environmental Chemistry, section 5.3 Global Warming and Climate Change.

30. The number of digits to the right of the decimal point denotes: (1)

A. Significant figures
B. ✓ **Decimal places**
C. Conversion factor
D. Scientific notation

> **Answer:** B
> The number of digits written to the right of the decimal point is called the number of decimal places. For example, 3.142 has three decimal places. So B is correct.
> Significant figures are different: they count all the meaningful digits in a measurement, on both sides of the decimal point.
> **Textbook:** Chemistry Grade 9, Unit 2 Measurements and Scientific Methods, section 2.1.7 Scientific Notation and Decimal Places.

31. Which of the following would occur during the formation of ions? (1)

A. Inner most shell electrons are involved.
B. Valence electrons are shared between atoms.
C. The electronic configuration of an atom forming the ion remains unaffected.
D. ✓ **Valence electrons are transferred from one atom to another.**

> **Answer:** D
> Ions form when one atom transfers its valence electrons to another. The atom that loses electrons becomes a positive ion and the one that gains them becomes a negative ion, so D is correct.
> A is wrong because only the outer (valence) electrons take part. B describes covalent bonding, not ion formation. C is wrong because the electron configuration of each atom changes when it becomes an ion.
> **Textbook:** Chemistry Grade 9, Unit 5 Chemical Bonding, section 5.2 Ionic Bonding (page 146).

32. In order to illustrate the structure and properties of a solid, a student put hundred marble balls in a box that representing metal cations and the empty space between and around the marble representing the electron sea. Which one of the following bonding is represented by this model? (1)

A. Covalent bonding
B. Ionic bonding
C. ✓ **Metallic bonding**
D. Dative bonding

> **Answer:** C
> The marbles stand for the positive metal ions arranged in a regular lattice, and the space around them stands for the sea of delocalized valence electrons. This picture is the electron-sea model, which describes metallic bonding, so C is correct.
> Covalent and dative bonds involve shared electron pairs between particular atoms, and ionic bonding involves oppositely charged ions, so none of them match the marble model.
> **Textbook:** Chemistry Grade 11, Unit 2 Chemical Bonding, section 2.4.2 Electron-Sea Model (page 112).

33. Which one of the following explains dipole-dipole force? (1)

A. A type of intermolecular force that exists between non-polar molecules.

B. ✓ **The intermolecular attraction between oppositely charged poles of nearby polar molecules.**

C. An attractive force resulting from temporary dipoles induced in molecules.

D. An electrostatic attraction between metal ions and valence electrons.

> **Answer:** B
> Polar molecules have a positive end and a negative end. A dipole-dipole force is the attraction between the positive pole of one polar molecule and the negative pole of a nearby polar molecule, so B is correct.
>
> A and C describe dispersion (London) forces, which act between non-polar molecules through temporary dipoles. D describes metallic bonding.
>
> **Textbook:** Chemistry Grade 11, Unit 2 Chemical Bonding, section 2.3.2 Intermolecular Forces in Covalent Compounds (page 107).

34. Which one of the following reactions creates energy in our bodies during respiration? (1)

A. ✓ **$C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$**

B. $6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(s) + 6O_2(g)$

C. $C_4H_8O_2(s) \rightarrow 2C_2H_5OH(l) + 2CO_2(g)$

D. $N_2H_4CO(g) + H_2O(g) \rightarrow 2NH_3(l) + CO_2(g)$

> **Answer:** A
> During respiration the body oxidizes glucose with the oxygen we breathe: C6H12O6 + 6O2 gives 6CO2 + 6H2O plus a large amount of energy. It is an exothermic reaction, so A is correct.
>
> B is photosynthesis, which absorbs energy from sunlight instead of releasing it. C is fermentation and D is a reaction of urea, neither of which powers our cells.
>
> **Textbook:** Chemistry Grade 12, Unit 5 Introduction to Environmental Chemistry, section 5.1 Introduction (natural cycles: respiration).

35. "A reaction that involves the exchange of positive and negative ions of each reactant". This is a definition of a: (1)

A. Decomposition reaction

B. Combination reaction

C. ✓ **Double displacement reaction**

D. Single displacement reaction

> **Answer:** C
> In a double displacement reaction two compounds swap their ions: the positive ion of one joins the negative ion of the other, as in AgNO3 + NaCl giving AgCl + NaNO3. The statement in the question is this definition, so C is correct.
>
> In a single displacement reaction only one element replaces another; in combination and decomposition reactions no exchange of partners happens.
>
> **Textbook:** Chemistry Grade 10, Unit 1 Chemical Reactions and Stoichiometry, section 1.3 Types of Chemical Reactions (page 11).

36. What are the four quantum numbers for an electron in a 2s orbital? (1)

A. 2, 1, 0, +½

B. 2, 1, 1, +½

C. ✓ **2, 0, 0, +½**

D. 2, 0, 1, +½

> **Answer:** C
> For a 2s electron: the principal quantum number n = 2, the s subshell means l = 0, l = 0 allows only $m_l = 0$, and the spin can be +1/2. So the set is 2, 0, 0, +1/2, answer C.
>
> Any set with l = 1 (options A and B) describes a p orbital, not s, and option D is impossible because when l = 0 the magnetic quantum number cannot be 1.
>
> **Textbook:** Chemistry Grade 11, Unit 1 Atomic Structure and Periodic Properties of the Elements, section 1.6.2 Quantum Numbers (page 36).

37. A student uses a digital balance (±0.02), a thermometer (±0.1), a measuring cylinder (±0.05), and a beaker (±0.5) during an experiment. Which of the above instrument is more precise? (1)

A. The thermometer

B. ✓ **The digital balance**

C. The Beaker

D. The measuring cylinder

> **Answer:** B
> The precision of an instrument is shown by its uncertainty: the smaller the uncertainty, the more precise the reading. Comparing them, the digital balance has the smallest uncertainty (plus or minus 0.02), so it is the most precise instrument, answer B.
>
> The beaker, with plus or minus 0.5, is the least precise of the four.
>
> **Textbook:** Chemistry Grade 9, Unit 2 Measurements and Scientific Methods, section 2.1.5 Precision and Accuracy.

38. Which one of the following explains that light has BOTH wave and particle nature? (1)

A. ✓ **A beam of light is a stream of particles of electromagnetic energy, with energy proportional to the observed frequency of the light.**

B. An electron that is bound to the nucleus behaves like a standing wave and its position is given in terms of probability.

C. Microscopic systems, such as atoms and molecules can possess wave properties.

D. Light consists of electromagnetic waves which have an oscillating electric and magnetic disturbance that spreads electromagnetic radiation.

> **Answer:** A
> Option A carries both ideas at once: light is a stream of particles (photons), which is the particle nature, and each photon's energy depends on the frequency of the light, which is a wave property. Linking particle energy to frequency (E = h times frequency) is exactly the wave-particle picture, so A is correct.
>
> D mentions only the wave side, and B and C are about electrons and matter, not light.
>
> **Textbook:** Chemistry Grade 11, Unit 1 Atomic Structure and Periodic Properties of the Elements, section 1.5.2 The Quantum Theory and Photon (page 18).

39. A nuclear breakdown in which particles or electromagnetic radiation is emitted is: (1)

A. Radioactive isotopes

B. Radioactivity

C. Radio wave

D. ✓ **Radioactive decay**

> **Answer:** D
> When an unstable nucleus breaks down, it gives off particles (such as alpha or beta particles) or electromagnetic radiation (gamma rays). This breakdown process is called radioactive decay, so D is correct.
>
> Radioactivity is the general phenomenon or property of emitting such radiation, and a radioactive isotope is the substance itself; the question asks for the name of the breakdown event.
>
> **Textbook:** Chemistry Grade 11, Unit 1 Atomic Structure and Periodic Properties of the Elements, section 1.3.2 Radioactivity and the Discovery of the Nucleus (page 9).

40. Which statement describes valence shell electron pair repulsion (VSEPR) theory? (1)

A. Each degenerate orbitals are occupied by a single electron before the second electrons of opposite spin enters the orbitals.

B. ✓ **Electron pairs will be as far apart from each other in three dimensional spaces as possible.**

C. Atomic orbitals are capable of combining to produce new electron distribution.

D. A covalent bond is formed when orbitals of two atoms overlap and the overlap region is occupied by a pair of electrons.

> **Answer:** B
>
> VSEPR theory says that the electron pairs around a central atom repel each other, so they arrange themselves in space as far apart as possible. This arrangement decides the shape of the molecule. Option B states this, so it is correct.
>
> A is Hund's rule, C describes molecular orbital formation, and D is the main idea of valence bond theory.
>
> **Textbook:** Chemistry Grade 11, Unit 2 Chemical Bonding, section 2.3.1 Molecular Geometry (page 100).

41. Which one of the following is a colorless, flammable volatile liquid and miscible with non-polar solvents? (1)

A. ✓ **Benzene**

B. Ethanol

C. Methanol

D. Methane

> **Answer:** A
>
> Benzene is a colorless, flammable and volatile liquid. It is non-polar, so it does not dissolve in water but mixes freely with non-polar solvents such as ether and carbon tetrachloride. This matches the description exactly, so A is correct.
>
> Methanol and ethanol are polar liquids that mix with water, and methane is a gas at room temperature, so none of them fit.
>
> **Textbook:** Chemistry Grade 10, Unit 6 Hydrocarbons and their Natural Sources, section 6.4.3 Physical Properties of Benzene.

42. The IUPAC name of the compound with the following structure is: (1)

A. 3, 4, 5-Trimethylhexane

B. 2-Ethyl-3, 4-dimethylpentane

C. 4-Ethyl-2, 3-dimethylpentane

D. ✓ **2, 3, 4-Trimethylhexane**

> **Answer:** D
>
> All four names describe the same skeleton: a six-carbon chain carrying three methyl groups on the middle carbons. The longest chain has six carbons, so the parent name is hexane, which rules out the pentane names in B and C (they use a shorter chain as parent).
>
> Numbering must start from the end that gives the substituents the lowest numbers: 2, 3, 4 rather than 3, 4, 5. So the correct name is 2,3,4-trimethylhexane, answer D.
>
> **Textbook:** Chemistry Grade 10, Unit 6 Hydrocarbons and their Natural Sources, section 6.2 Saturated Hydrocarbons: Alkanes (page 244).

43. Which one of the following petroleum products is used as a solvent and in dry cleaning? (1)

A. kerosene

B. ✓ **Petroleum ether**

C. Paraffin wax

D. Diesel oil

> **Answer:** B
>
> Petroleum ether is the light fraction collected early in the fractional distillation of petroleum. The textbook lists its uses as a solvent and in dry cleaning, so B is correct.
>
> Kerosene is a fuel for lamps and jets, paraffin wax is used for candles and coatings, and diesel oil runs diesel engines.
>
> **Textbook:** Chemistry Grade 10, Unit 6 Hydrocarbons and their Natural Sources, section 6.5 Natural Sources of Hydrocarbons (page 293).

44. Which one of the following is NOT TRUE about laboratory preparation of ethylene by dehydration of ethanol? (1)

A. The collected ethylene gas in the experiment decolorizes Br_2 in CCl_4.

B. Concentrated sulphuric acid is used as a dehydrating agent.

C. Combustion of ethylene produces a non-luminous flame.

D. ✓ **The collected ethylene gas in the experiment alkaline $KMnO_4$.**

> **Answer:** D
> In the laboratory, ethylene (ethene) is prepared by heating ethanol with concentrated sulphuric acid to about 170 degrees Celsius; the acid acts as the dehydrating agent, so B is true. The collected gas is unsaturated: it decolorizes bromine solution and also decolorizes alkaline KMnO4 (Baeyer's test), so A is true.
>
> A statement claiming the gas does not decolorize alkaline KMnO4 would be false, and that is what option D is recorded as testing.
>
> **Textbook:** Chemistry Grade 10, Unit 6 Hydrocarbons and their Natural Sources, section 6.3 Unsaturated Hydrocarbons (Experiment 6.3, Laboratory Preparation of Ethene).

45. Which one of the following is an essential nutrient of plants? (1)

A. Aluminum

B. Lead

C. Sodium

D. ✓ **Potassium**

> **Answer:** D
> Plants need three primary nutrients in large amounts: nitrogen, phosphorus and potassium, the N, P and K of fertilizer labels. Potassium is on the list, so D is correct.
>
> Aluminum and lead are not plant nutrients (lead is toxic), and sodium is not one of the essential fertilizer elements.
>
> **Textbook:** Chemistry Grade 10, Unit 3 Important Inorganic Compounds, section 3.5 Salts (fertilizers and the NPK elements).

46. Which one of the following is the main reason for the large difference in dipole-moment between the triatomic molecules water (H_2O) and carbon dioxide (CO_2)? (1)

A. The presence of lone pairs of electrons in water (H_2O) partially reinforces bond polarities.

B. The higher electronegativity difference among atoms in water (H_2O) than can carbon dioxide (CO_2).

C. The presence of multiple bonds in carbon dioxide (CO_2) while single bonds in water.

D. ✓ **The bonds in carbon dioxide (CO_2) are directed 180° and bond polarity reinforces each other.**

> **Answer:** D
> Both molecules have polar bonds, but geometry decides the overall dipole. CO2 is linear: its two bond dipoles point in opposite directions along the 180 degree axis and cancel, so CO2 has zero dipole moment. Water is bent, so its two bond dipoles add up, giving a large dipole moment. The geometric argument about the 180 degree bonds in CO2 is the intended answer, D.
>
> **Textbook:** Chemistry Grade 11, Unit 2 Chemical Bonding, section 2.3.1 Molecular Geometry (page 100).

47. Which one would be observed in a laboratory activity that is applied on naphthalene? (1)

A. ✓ **It is soluble in benzene.**

B. It conducts electricity in molten state.

C. It shows relatively high melting point.

D. It is soluble in water.

> **Answer:** A
> Naphthalene is a non-polar covalent (molecular) solid. Like dissolves like, so it dissolves in benzene, a non-polar solvent, and not in water. So A is what the experiment shows.
>
> B and C describe ionic solids: naphthalene does not conduct when molten and it melts at a low temperature (about 80 degrees Celsius) because only weak intermolecular forces hold its molecules together.
>
> **Textbook:** Chemistry Grade 11, Unit 2 Chemical Bonding (solubility of covalent compounds such as naphthalene in polar and non-polar solvents).

48. Which one of the following statements is CORRECT? (1)

A. Valence bond model simply shows the linkage between atoms and the presence of lone pairs.

B. Lewis model predicts the shapes of molecules based on electron-pair repulsions around a central atom.

C. In Lewis model, electrons repel one another and a pair of bonding electrons lie far apart as possible.

D. ✓ **Valence bond model explain molecular shape from the interaction of atomic orbitals.**

> **Answer:** D
> Valence bond theory explains bonding and molecular shape through the interaction (overlap) of atomic orbitals, helped by hybridization. That is what D says, so D is the correct statement.
>
> A mixes up valence bond theory with the Lewis model: it is the Lewis structure that simply shows linkages and lone pairs. B and C give the Lewis model the job of VSEPR theory; the textbook states plainly that the Lewis model gives no idea about the shapes of molecules.
>
> **Textbook:** Chemistry Grade 11, Unit 2 Chemical Bonding, section 2.5.1 Valence Bond (VB) Theory (page 115).

49. The energy required to completely separate one mole of a solid ionic compound into gaseous ions is a: (1)

A. Ionization energy

B. Activation energy

C. ✓ **Lattice energy**

D. Bond energy

> **Answer:** C
> Lattice energy is the energy needed to separate one mole of a solid ionic compound completely into its gaseous ions. The definition in the question matches this, so C is correct.
>
> Ionization energy removes an electron from a gaseous atom, bond energy breaks a covalent bond, and activation energy is the energy barrier of a reaction.
>
> **Textbook:** Chemistry Grade 11, Unit 2 Chemical Bonding, section 2.2 Ionic Bonds (page 69).

50. Which of the following compounds reacts with basic oxide to form salt and water? (1)

A. ✓ **Acid**

B. Acidic oxide

C. Base

D. Neutral oxide

> **Answer:** A
> A basic oxide, such as CaO or Na2O, reacts with an acid to give a salt and water. For example, CaO + 2HCl gives CaCl2 + H2O. So the substance that reacts with a basic oxide this way is an acid, answer A.
>
> A base or another basic oxide would not neutralize a basic oxide, and a neutral oxide does not react this way at all.
>
> **Textbook:** Chemistry Grade 10, Unit 3 Important Inorganic Compounds, section 3.2 Oxides (page 113).

51. Which one of the following reaction represents formation of an acid from its salt? (1)

A. $CH_3COOH(aq) + CH_3OH(aq) \rightarrow CH_3COOCH_3(aq) + H_2O(l)$

B. $P_2O_5(s) + 6NaOH(aq) \rightarrow 2Na_3PO_4(s) + 3H_2O(l)$

C. ✓ **$NaNO_2(s) + H_2SO_4(l) \rightarrow NaHSO_4(s) + HNO_2(l)$**

D. $AgNO_3(aq) + NaCl(aq) \rightarrow NaNO_3(aq) + AgCl(s)$

> **Answer:** C
> A less volatile acid can displace a more volatile acid from its salt. In option C, sulphuric acid acts on sodium nitrite (a salt) and sets free nitrous acid, HNO2. A salt is converted into an acid, so C shows formation of an acid from its salt.
>
> A is esterification, B is a base reacting with an acidic oxide, and D is a precipitation reaction between two salts.
>
> **Textbook:** Chemistry Grade 10, Unit 3 Important Inorganic Compounds, section 3.3 Acids (page 124).

52. The negative logarithm of the molar concentration of hydrogen ion to the base ten is known as: (1)

A. ✓ **pH**
B. Kw
C. Ka
D. pOH

Answer: A
pH is defined as the negative logarithm, to base ten, of the molar hydrogen ion concentration: pH = -log[H+]. The question restates this definition, so A is correct.
pOH plays the same role for OH- ions, Kw is the ion product of water, and Ka is the acid ionization constant.
Textbook: Chemistry Grade 12, Unit 1 Acid-Base Equilibria, section 1.2 Ionic Equilibria of Weak Acids and Bases.

53. Which one of the following galvanic cell is an example of secondary cell? (1)

A. Daniel's cell
B. ✓ **Lead storage cell**
C. Leclanche dry cell
D. Zinc-carbon dry cell

Answer: B
A secondary cell can be recharged: passing current backwards reverses the electrode reactions so the cell can be used again and again. The lead storage (lead-acid) battery used in cars is the classic secondary cell, so B is correct.
The Daniell cell, the Leclanche dry cell and the zinc-carbon dry cell are primary cells; once their chemicals are used up they are thrown away.
Textbook: Chemistry Grade 12, Unit 2 Electrochemistry, section 2.5 Voltaic Cells.

54. Which one of the following is responsible for electrolytic conductivity? (1)

A. Ions strongly held in a fixed position.
B. Free electrons.
C. Electrons held in a fixed position.
D. ✓ **Movement of ions.**

Answer: D
An electrolyte conducts because its ions are free to move: positive ions drift toward the cathode and negative ions toward the anode, carrying the current. So electrolytic conductivity is due to the movement of ions, answer D.
Free electrons are the carriers in metals, not in electrolytes, and ions fixed in place (as in a solid ionic crystal) cannot conduct.
Textbook: Chemistry Grade 12, Unit 2 Electrochemistry, section 2.2 Electrolysis of Aqueous Solutions (electrolytic conduction).

55. Which one of the following statement is TRUE about gases? (1)

A. The particles of gases are closely packed together.
B. The volume of a gas is kept constant as pressure increases.
C. When a gas sample is heated at constant pressure, its volume decreases.
D. ✓ **The volume of a gas is equal to the volume of its container.**

Answer: D
Gas particles are far apart and move freely, so a gas spreads out to fill whatever container it is in. Its volume is therefore the volume of the container, making D true.
A describes solids and liquids. B contradicts Boyle's law: increasing pressure compresses a gas. C contradicts Charles's law: heating a gas at constant pressure expands it.
Textbook: Chemistry Grade 11, Unit 3 Physical States of Matter, section 3.3 The Gaseous State (page 150).

56. Which one of the following mathematical expressions is derived from the combination of Boyle's law, Charles' law and Avogadro's law? (1)

A. ✓ **Va ∝ nT/P**

B. Va ∝ T/nP

C. Va ∝ nP/T

D. Va ∝ P/nT

> **Answer:** A
>
> Boyle's law gives V proportional to 1/P, Charles's law gives V proportional to T, and Avogadro's law gives V proportional to n. Combining the three: $V \propto \frac{nT}{P}$, which is option A. Adding the constant R turns this into the ideal gas equation PV = nRT.
>
> The other options put P or T on the wrong side of the fraction.
>
> **Textbook:** Chemistry Grade 11, Unit 3 Physical States of Matter, section 3.3.2 The Gas Laws (page 153).

57. 180 g of calcium carbonate ($CaCO_3$) is allowed to react with 156 gram of hydrochloric acid (HCl), according to the following reaction. Which of the following substances is the limiting reagent? (Atomic masses; Ca=40, Cl 35.5, O=16, C=12, H=1) $CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$ (1)

A. HCl

B. ✓ **$CaCO_3$**

C. H_2O

D. CO_2

> **Answer:** B
>
> Work out the moles of each reactant. CaCO3: molar mass = 40 + 12 + 48 = 100 g/mol, so $180 \div 100 = 1.8$ mol. HCl: molar mass = 36.5 g/mol, so $156 \div 36.5 = 4.27$ mol.
>
> The equation needs 2 mol HCl per mol CaCO3, so 1.8 mol CaCO3 needs $2 \times 1.8 = 3.6$ mol HCl. Since 4.27 mol HCl is available, HCl is in excess and CaCO3 runs out first. CaCO3 is the limiting reagent, answer B.
>
> **Textbook:** Chemistry Grade 10, Unit 1 Chemical Reactions and Stoichiometry, section 1.6 Stoichiometry (page 34).

58. Which one of the following isomers differs in the arrangement of carbon atoms in the longest continuous carbon chain? (1)

A. Geometric

B. Position

C. Cis-trans

D. ✓ **Structural**

> **Answer:** D
>
> Isomers that differ in how the carbon atoms are arranged in the chain (for example butane and 2-methylpropane) are structural isomers; this kind is often called chain isomerism. So D is correct.
>
> Geometric (cis-trans) isomers have the same skeleton and differ only in the spatial arrangement around a double bond, and position isomers differ in where a substituent or functional group sits, not in the chain itself.
>
> **Textbook:** Chemistry Grade 10, Unit 6 Hydrocarbons and their Natural Sources, section 6.2 Saturated Hydrocarbons: Alkanes (structural isomerism).

59. Which one of the following methods can be used in the laboratory for the preparation of alkynes? (1)

A. Dehydration of alcohols with concentrated sulphuric acid.

B. Heating of sodium salt of an organic acid with soda lime.

C. ✓ **Dehydrohalogenation of adjacent dihalides with sodium hydroxide.**

D. Hydrogenation of alkenes with a metal catalyst.

> **Answer:** C
>
> Alkynes are prepared in the laboratory by dehydrohalogenation of vicinal (adjacent) dihalides: a base such as NaOH or KOH removes HX twice, creating the triple bond. So C is correct.
>
> Dehydration of alcohols (A) gives alkenes, heating a sodium salt of an organic acid with soda lime (B) gives alkanes, and hydrogenating alkenes (D) also gives alkanes.
>
> **Textbook:** Chemistry Grade 10, Unit 6 Hydrocarbons and their Natural Sources, section 6.3 Unsaturated Hydrocarbons (preparation of alkynes).

60. In a kinetic experiment, a student placed crystals of iodine in a closed reaction vessel, introduced a given quantity of hydrogen gas, and collected data to calculate the rate of formation of hydrogen iodide. What would be the effect obtained on the rate of the reaction, if the student takes more amount of iodine from that used in the first experiment? (1)

A. It speeds up the rate of the reaction.

B. It lowers the rate of the reaction.

C. The formation of hydrogen iodide will be decreased.

D. ✓ **The rate of the reaction will be constant.**

> **Answer:** D
> Iodine is present as a solid. A pure solid keeps a fixed vapor concentration above it at a given temperature, no matter how much solid is there. The reaction happens between hydrogen gas and iodine vapor, and the concentration of that vapor does not change when extra crystals are added. So the rate stays the same, answer D.
>
> Amounts of pure solids never appear in rate laws or equilibrium expressions; only the gas or solution concentrations count.
>
> **Textbook:** Chemistry Grade 11, Unit 4 Chemical Kinetics, section 4.3 Factors Affecting the Rate of a Chemical Reaction (page 207).

61. Which of the following CORRECTLY relates the vapor pressure of a liquid with its boiling point? (1)

A. the temperature at which all the three physical state co-exist.

B. ✓ **the temperature at which the vapor pressure becomes equal to the external pressure.**

C. the temperature at which molecules present in the vapor phase go back to the liquid state.

D. the temperature at which the kinetic energy of molecules is much less than the intermolecular force.

> **Answer:** B
> A liquid boils when its vapor pressure grows large enough to equal the external (atmospheric) pressure; at that temperature bubbles of vapor can form inside the liquid. So the boiling point is the temperature at which vapor pressure equals external pressure, answer B.
>
> A defines the triple point and C describes condensation, not boiling.
>
> **Textbook:** Chemistry Grade 11, Unit 3 Physical States of Matter, section 3.4 The Liquid State (page 173).

62. Consider this equilibrium system: $CO(g) + Fe_3O_4(s) \rightleftharpoons CO_2(g) + 3FeO(s)$. Which of the following disturbances shift the equilibrium position to the right? (1)

A. ✓ **Removing $CO_2(g)$**

B. Removing CO(g)

C. Removing FeO(s)

D. Adding $Fe_3O_4(s)$

> **Answer:** A
> By Le Chatelier's principle, removing a product pulls the equilibrium toward making more of it. Removing CO2 makes the system shift right to replace the lost CO2, so A is correct.
>
> Removing the reactant CO would shift the position left. Fe3O4 and FeO are pure solids, so adding or removing them does not shift the equilibrium at all.
>
> **Textbook:** Chemistry Grade 11, Unit 5 Chemical Equilibrium, section 5.2.6 Changing Equilibrium Conditions: Le Chatelier's Principle (page 245).

63. Which one of the following resulted from interaction of the atomic orbitals of bonding atoms to produce new electron distribution associated with the entire molecule? (1)

A. Hybrid orbital
B. ✓ **Molecular orbital**
C. Electron orbit
D. Bohr orbit

> **Answer:** B
> In molecular orbital theory, the atomic orbitals of the bonding atoms combine to form new orbitals that belong to the molecule as a whole. These new electron distributions over the entire molecule are molecular orbitals, so B is correct.
> Hybrid orbitals are different: they are mixtures of orbitals on one single atom, not orbitals spread over the whole molecule.
> **Textbook:** Chemistry Grade 11, Unit 2 Chemical Bonding, section 2.5.2 Molecular Orbital Theory (page 131).

64. Which type of organic substances would be produced by heating a mixture of a carboxylic acid and an alcohol in the presence of H_2SO_4? (1)

A. Ketones
B. Aldehydes
C. ✓ **Esters**
D. Ethers

> **Answer:** C
> Heating a carboxylic acid with an alcohol in the presence of concentrated H2SO4 is esterification: the acid and the alcohol join, water is removed, and an ester forms. So the products are esters, answer C.
> Aldehydes and ketones come from oxidizing alcohols, and ethers come from dehydrating two alcohol molecules, not from an acid plus an alcohol.
> **Textbook:** Chemistry Grade 11, Unit 6 Some Important Oxygen-Containing Organic Compounds, section 6.5 Esters (page 313).

65. Which one of the following is the reducing agent in the following reaction? $8NH_3(g) + 6NO_2(g) \rightarrow 7N_2(g) + 12H_2O(l)$ (1)

A. NO_2
B. ✓ **NH_3**
C. H_2O
D. N_2

> **Answer:** B
> Assign oxidation numbers to nitrogen. In NH3 nitrogen is -3; in NO2 it is +4; in N2 it is 0. Nitrogen in NH3 goes from -3 to 0, so NH3 loses electrons and is oxidized. The substance that is oxidized is the reducing agent, so NH3 is the reducing agent, answer B.
> NO2 goes from +4 to 0, so it is reduced and acts as the oxidizing agent.
> **Textbook:** Chemistry Grade 12, Unit 2 Electrochemistry, section 2.1 Oxidation-Reduction Reactions.

66. Carbon forms two stable compounds with oxygen, namely, carbon monoxide and carbon dioxide. For a fixed mass of carbon, the ratio of oxygen in carbon monoxide to oxygen in carbon dioxide is 1:2. This result is consistent with the law of: (1)

A. definite proportion.
B. conservation of mass.
C. constant composition.
D. ✓ **multiple proportion.**

> **Answer:** D
> Here one fixed mass of carbon combines with two different masses of oxygen, and those oxygen masses stand in the simple ratio 1 to 2. When the masses of one element that combine with a fixed mass of another form a small whole-number ratio, that is the law of multiple proportions, answer D.
> The law of definite proportions (also called constant composition) is about one single compound always having the same composition, so A and C do not fit two different compounds.
> **Textbook:** Chemistry Grade 9, Unit 3 Structure of the Atom, section 3.2.3 The Law of Multiple Proportions.

67. When a system at equilibrium is disturbed by a change of variable, the system shifts the equilibrium position in a way that tends to counteract this change of variable. This is a statement for: (1)

A. Pauli's exclusion principle
B. Aufbau principle
C. Heisenberg uncertainty principle
D. ✓ **Le Chatelier Principle**

> **Answer:** D
> This is the statement of Le Chatelier's principle: when an equilibrium system is disturbed (by a change in concentration, pressure or temperature), it shifts in the direction that opposes the disturbance. So D is correct.
>
> The Pauli, Aufbau and Heisenberg principles all belong to atomic structure and electron arrangement, not to chemical equilibrium.
>
> **Textbook:** Chemistry Grade 11, Unit 5 Chemical Equilibrium, section 5.2.6 Changing Equilibrium Conditions: Le Chatelier's Principle (page 245).

68. Which one of the following gas laws states the volume of a fixed amount of gas maintained at constant pressure is directly proportional to the absolute temperature of the gas? (1)

A. ✓ **Charles's law**
B. Boyle's law
C. Avogadro's law
D. Combined gas law

> **Answer:** A
> Charles's law states that the volume of a fixed amount of gas at constant pressure is directly proportional to its absolute (Kelvin) temperature: V/T is constant. That is the statement in the question, so A is correct.
>
> Boyle's law relates volume to pressure at constant temperature, and Avogadro's law relates volume to the number of moles.
>
> **Textbook:** Chemistry Grade 11, Unit 3 Physical States of Matter, section 3.3.2 The Gas Laws (page 153).

69. The pH of a 0.1 M solution of formic acid (HCOOH) is 3. What is the Ka of the acid? (1)

A. ✓ **1.01×10^{-5}**
B. 1.01×10^{-7}
C. 9.99×10^{-4}
D. 9.99×10^{-5}

> **Answer:** A
> pH 3 means [H+] = 10^{-3} M. Each ionized HCOOH gives one H+ and one HCOO−, so both ions are 10^{-3} M, and the acid left un-ionized is $0.1 - 0.001 = 0.099$ M.
>
> $K_a = \frac{(10^{-3}) \times (10^{-3})}{0.099} = \frac{10^{-6}}{0.099} = 1.01 \times 10^{-5}$, answer A.
>
> Option B (1.01×10^{-7}) comes from a power-of-ten slip; keep track of the exponents when squaring 10^{-3}.
>
> **Textbook:** Chemistry Grade 12, Unit 1 Acid-Base Equilibria, section 1.2 Ionic Equilibria of Weak Acids and Bases.

70. A system does 15 J of work and no other changes take place. Which of the following functions has fallen by 15 J? (1)

A. ✓ **Internal energy**
B. Specific heat
C. Enthalpy
D. Entropy

> **Answer:** A
> By the first law of thermodynamics, the change in internal energy is the heat added plus the work done on the system. Here no heat flows and the system itself does 15 J of work on the surroundings, so its internal energy falls by exactly 15 J. Answer A.
>
> Enthalpy and entropy are not simply equal to the work done, and specific heat is a property of a material, not an energy store.
>
> **Textbook:** Chemistry Grade 10, Unit 4 Energy Changes and Electrochemistry, section 4.1 Introduction (internal energy).

71. Which of the following is CORRECTLY stated about the spontaneity of a reaction? (1)

A. For an endothermic reaction with negative reaction entropy, the reaction is spontaneous at all temperature.

B. For an exothermic reaction with positive reaction entropy, the reaction is non-spontaneous at all temperature.

C. ✓ **For an endothermic reaction with positive reaction entropy, the reaction is non-spontaneous at low temperature.**

D. For an exothermic reaction with negative reaction entropy, the reaction is spontaneous at high temperature.

Answer: C

Spontaneity follows the sign of the free energy change: delta G = delta H minus T delta S. For an endothermic reaction (delta H positive) with positive entropy change, delta G is positive at low temperature and only becomes negative when T is large. So such a reaction is non-spontaneous at low temperature and spontaneous at high temperature, which is what C says.

A is wrong: positive delta H with negative delta S is never spontaneous. B is wrong: negative delta H with positive delta S is spontaneous at every temperature. D is wrong: that combination is spontaneous at low temperature, not high.

72. In thermodynamics, solutions in a beaker, a gas in a cylinder, a reaction vessel, a biological cell are examples of: (1)

A. thermodynamic variables

B. state function

C. path function

D. ✓ **thermodynamic system**

Answer: D

In thermodynamics, the system is the part of the universe we choose to study, and everything else is the surroundings. A solution in a beaker, a gas in a cylinder, a reaction vessel and a living cell are each a chosen part of the universe under study, so they are examples of thermodynamic systems, answer D.

State functions and path functions are quantities (like internal energy or work), not objects of study.

Textbook: Chemistry Grade 10, Unit 4 Energy Changes and Electrochemistry, section 4.1 Introduction (system and surroundings).

73. The rate law for: $(CH_3)_3C\text{-}Br(aq) + H_2O(l) \rightarrow (CH_3)_3C\text{-}OH(aq) + H^+ + Br^-(aq)$ is rate = $k[(CH_3)_3C\text{-}Br]$. The accepted mechanism for the reaction is... Why DOES NOT H_2O appear in the rate law? Because: (1)

A. water is a catalyst in the reaction.

B. water is an intermediate species.

C. water exists in the liquid state in the reaction.

D. ✓ **water is missing in the rate determining step.**

Answer: D

A rate law contains only the species that take part in the slow, rate-determining step. For this reaction the slow step is the breaking of the C-Br bond in (CH3)3C-Br to form a carbocation; water attacks that carbocation only in a later, fast step. Because water enters after the rate-determining step, it does not appear in the rate law, answer D.

Water is a reactant here, not a catalyst, and it is not an intermediate (intermediates are formed and then used up, like the carbocation).

Textbook: Chemistry Grade 11, Unit 4 Chemical Kinetics, section 4.2 The Rate of a Reaction (page 193).

74. Which type of substances has the following general formula? (R_1, R_2 and R_3 hydrocarbon groups.) (1)

A. Carboxylic acids
B. ✓ **Fats**
C. Alcohols
D. Fatty acids

Answer: B

A general formula with three hydrocarbon groups R1, R2 and R3 attached through three ester linkages to one glycerol backbone is a triglyceride. Fats and oils are exactly these triesters of glycerol with fatty acids, so B is correct.

An alcohol has one OH group, a carboxylic acid has one COOH group, and a fatty acid is a single long-chain acid, so none of them carry three R groups on one molecule.

Textbook: Chemistry Grade 11, Unit 6 Some Important Oxygen-Containing Organic Compounds, section 6.6.2 Structure of Fats and Oils (page 320).

75. The speed with which a solute goes into solution is: (1)

A. degree of solvation
B. heat of solution
C. ✓ **rate of dissolution**
D. extent of dissolution

Answer: C

The speed with which a solute dissolves is called the rate of dissolution. It grows with stirring, heating and grinding the solute into smaller pieces, because all of these help solvent molecules reach the solute faster. So C is correct.

How much can dissolve in total is the solubility (the extent, not the speed), and the heat of solution is the energy change, not a rate.

Textbook: Chemistry Grade 10, Unit 2 Solutions, section 2.2.5 The Rate of Dissolution.

76. Which one of the following explains how 2 L of 1 M NaOH aqueous stock solution is converted into a 0.25 M NaOH solution? (1)

A. ✓ **Adding 6 L water to the stock solution**
B. Adding 8 L water to the stock solution
C. Evaporating 0.25 L of water from the stock solution
D. Evaporating 1 L of water from the stock solution

Answer: A

Dilution keeps the moles of solute constant: $C_1V_1 = C_2V_2$. Here $1 \times 2 = 0.25 \times V_2$, so $V_2 = 8$ L.

The final volume must be 8 L, and we already have 2 L, so we add 6 L of water. Answer A.

Evaporating water (options C and D) removes solvent and would make the solution more concentrated, not more dilute.

Textbook: Chemistry Grade 10, Unit 2 Solutions, section 2.5 Preparation of Solutions (page 95).

— END OF MARKING KEY —