

Chemistry, 2017 EC, entrance exam, version 2

Grade 12 · Chemistry · 2017 E.C.

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1. Which of the following is correct about the postulates of Thomson's experiment? (1)

- A. Cathode rays are made of positively charged particles, later called electrons.
- B. Electrons are NOT present in all atoms of all elements.
- C. Electrons have a very large mass compared to the atom.
- D. ✓ Cathode rays travel in straight lines and can be deflected by electric and magnetic fields

Answer: D

In the cathode ray tube the rays cast a sharp shadow of any object placed in the beam, which shows they travel in straight lines. When Thomson put an electric field and then a magnetic field across the tube, the beam bent, and the direction of the bend showed the particles carry negative charge. Those two observations together are what option D states. Option A is tempting because it names the electron correctly, but it calls the particles positive, and the deflection Thomson measured showed the opposite.

2. Imagine you are a scientist in the 19th century and want to improve Dalton's Atomic Theory. Which of the following new experiments would best refine his ideas? (1)

- A. ✓ Designing a cathode ray tube experiment to identify subatomic particles.
- B. Proposing that all atoms are made of fire, water, air, and earth
- C. Conducting an experiment to prove that atoms cannot form compounds.
- D. Showing that atoms of the same element have completely different masses.

Answer: A

Dalton's biggest error was treating the atom as a solid ball that cannot be divided. To improve on it you need an experiment that looks inside the atom, and the cathode ray tube did exactly that: it produced electrons, particles far smaller than any atom, from whatever metal was used. Option D is the tempting one because isotopes really did refine Dalton's picture of atomic mass, but atoms of one element differ only slightly in mass, not completely, and that experiment leaves the indivisible atom untouched.

3. The atomic mass of element A is 91 atomic mass unit. The only naturally occurring isotopes of element A are A-90 and A-94. The percent abundance in naturally occurring sample of element A are (1)

- A. 31% A-90 and 69% A-94
- B. ✓ 75% A-90 and 25% A-94
- C. 69% A-94 and 31% A-90
- D. 20% A-94 and 80% A-90

Answer: B

Let x be the fraction of A-90, so $1 - x$ is the fraction of A-94. The weighted average gives $90x + 94(1 - x) = 91$, which becomes $94 - 4x = 91$, so $x = 0.75$. That is 75% A-90 and 25% A-94. A quick sense check: 91 sits much closer to 90 than to 94, so the light isotope has to be the common one. Options A and C put most of the sample on A-94, which would pull the average above 92.

4. Which of the following statements best explains the relationship between electrons' energy levels and the emission spectra of atoms? (1)
- A. ✓ **Electrons absorb energy on jumping from lower to higher energy level**
- B. Electron emit energy on revolving around the nucleus
- C. Electron absorb energy on revolving around the nucleus
- D. The emission spectra are unrelated to electron transitions but depend on atomic size.

Answer: A

Line spectra exist because an atom's electrons can only sit at fixed energy levels. When an electron takes in energy it jumps to a higher level, and when it drops back it gives out a photon whose energy equals the gap it fell through. Fixed gaps give fixed photon energies, which is why the spectrum is a set of sharp lines instead of a smooth band. Option B is tempting because the Bohr picture has electrons moving around the nucleus, but an electron in a stable level does not radiate; energy is only exchanged when it changes level.

5. Which one of the following sets of quantum numbers could be those of the distinguishing (last) electron of Cr at s-orbital? (1)
- A. $n = 3, l = 0, m_l = 0, m_s = +1/2$
- B. $n = 3, l = 2, m_l = -1, m_s = +1/2$
- C. $n = 4, l = 1, m_l = 3, m_s = -1/2$
- D. ✓ **$n = 4, l = 0, m_l = 0, m_s = -1/2$**

Answer: D

Chromium is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$, and the question asks for its electron in an s orbital, which is the 4s one. A 4s orbital means $n = 4$ and $l = 0$, and when $l = 0$ the only allowed value is $m_l = 0$. Set D matches. Option A is tempting because it also has $l = 0$, but $n = 3$ describes a 3s electron buried in an inner shell, not the outermost one.

6. A radio station broadcasts at a frequency of 100 MHz. What is the wavelength of the radio waves? (Speed of light, $c = 3.00 \times 10^8$ m/s) (1)
- A. 3.0×10^{-3} m
- B. ✓ **3.0 m**
- C. 3.0×10^6 m
- D. 3.0×10^{-3} m

Answer: B

The prefix M means mega, or 10^6 , so 100 MHz is 1.00×10^8 Hz. Wavelength comes from $\lambda = c/f$, which gives $\lambda = (3.00 \times 10^8)/(1.00 \times 10^8) = 3.0$ m. Option C is the trap: it comes from dividing by 100 instead of by 10^8 , which means forgetting to convert megahertz into hertz.

7. The photoelectric effect can be observed when: (1)
- A. Light with low intensity shined on a metal surface.
- B. ✓ **Light of sufficient frequency shining and ejects electrons from a metal**
- C. Electrons jump to higher energy levels when exposed to light
- D. The intensity of light is increased with decreasing frequency

Answer: B

Light arrives in packets, and each packet carries energy $E = hf$. An electron only escapes the metal when one packet on its own carries more than the metal's work function, so the light must be above a threshold frequency. Option A is the tempting one, because it sounds as though more light should help, but raising the intensity of low frequency light only sends more weak packets. Not one of them can free an electron, so no current flows however bright the lamp is.

8. Which of the following molecules is correctly matched with its geometry? (1)
- A. IF_5 - Trigonal pyramidal B. PCl_3 - Trigonal bipyramidal
- C. ✓ **BrF_3 - T-shape** D. SF_4 - Square pyramidal

Answer: C

Bromine in BrF_3 has three bonding pairs and two lone pairs, which is the AX_3E_2 case. Five electron groups arrange as a trigonal bipyramid, and the two lone pairs take the roomy equatorial positions, leaving the three atoms in a T shape. Option A is tempting because IF_5 does look pyramidal in a drawing, but iodine there has five bonds and one lone pair (AX_5E), which gives a square pyramid, not a trigonal one.

9. Which of the following is TRUE about periodic trend of elements? (1)
- A. Ionization energy increases down a group
- B. ✓ **Atomic size decreases across a period**
- C. Both atomic size and electron affinity have the same periodic trend.
- D. Effective nuclear charge increases down a group.

Answer: B

Moving across a period, each step adds a proton to the nucleus while the new electron enters the same shell. Shielding barely changes, so the effective nuclear charge felt by the outer electrons rises and the shell is pulled in tighter. The atoms therefore get smaller from left to right. Option D is the tempting one, but going down a group each new shell adds shielding, so the effective nuclear charge on the outermost electrons does not rise the way it does across a period.

10. Which of the following best describes the nature of chemical bonds? (1)
- A. A repulsive force that separates atoms
- B. A temporary interaction between particles
- C. ✓ **An attractive force that holds atoms or ions together**
- D. A force that changes atomic nuclei

Answer: C

A chemical bond is the net attractive force that holds atoms or ions together in a compound, whether the electrons are transferred as in ionic bonding or shared as in covalent bonding. Atoms bond because the joined arrangement has lower energy than the separate atoms. Option B is the tempting one, because weak forces between particles do exist, but a bond is a lasting attraction that keeps the atoms in a fixed arrangement rather than a passing interaction.

11. Which of the following condition favors the formation of an ionic bond? (1)
- A. ✓ **Low ionization energy of metal and high electron affinity of non-metal**
- B. High ionization energy of metal and low ionization energy of non-metal
- C. High electron affinity of metals and low ionization energy of non-metal
- D. Large atomic size of nonmetal

Answer: A

An ionic bond forms when an electron actually moves from the metal to the nonmetal, and the two ions then attract. That transfer is cheap when the metal has a low ionization energy, so it gives its electron up easily, and profitable when the nonmetal has a high electron affinity, so it releases energy on taking the electron in. Option B is the tempting one because it uses the same words, but it demands a high ionization energy from the metal, which would make the metal hold on to its electron and stop the transfer.

12. The electron set geometries of NH_3 and H_2O molecules are distorted tetrahedral but bond angle in water is less than that of ammonia. Why? (1)

- A. ✓ **LP-LP of H_2O repel strongly than LP-BP of NH_3 does**
B. LP-BP of H_2O repel strongly than LP-BP of NH_3 does
C. Generally lone pair-lone pair repulsion is weaker than lone pair-bond pair repulsion
D. H_2O is polar and NH_3 is non-polar

Answer: A

Both molecules have four electron groups around the central atom, so both start from a tetrahedral electron arrangement. Water has two lone pairs on oxygen while ammonia has one on nitrogen, and lone pair to lone pair repulsion is the strongest of the three kinds. The extra squeeze pushes water's bond angle down to about 104.5° against ammonia's 107° . Option C states the ranking backwards, since lone pair to lone pair repulsion is the stronger of the two, not the weaker.

13. Which of the following is NOT true about properties of metallic bonding? (1)

- A. It gives rise to excellent electrical conductivity
B. Valence electrons are free to move throughout the structure
C. ✓ **The conductivity of electric current is due to the presence of free ions**
D. The strength of metallic bond affects physical properties of metals

Answer: C

In a metal the atoms give their valence electrons to a shared pool, leaving positive ions fixed in the lattice while the electrons drift freely. The current is carried by those delocalised electrons, so option C is the false statement and therefore the answer. Free ions do carry current, but in molten salts and in solutions, not in a solid metal. Option B is tempting to pick because it also mentions free particles, but it is a true statement about metals, so it cannot be the one you want.

14. According to Molecular orbital theory, which of the following species does NOT exist? (1)

- A. O_2^{2-}
B. ✓ **He_2**
C. O_2
D. C_2

Answer: B

Molecular orbital theory gives bond order as the number of bonding electrons minus the number of antibonding electrons, all divided by two. He_2 would have four electrons: two filling σ_{1s} and two filling σ_{1s}^* , so the bond order is $(2 - 2)/2 = 0$. A bond order of zero means there is no net bond, so the molecule does not exist. Option A is tempting because O_2^{2-} carries extra electrons in antibonding orbitals, but it still comes out with bond order 1 and exists as the peroxide ion.

15. Which of the following molecules is the WRONG combination arrangement of the molecules with their respective molecular geometry? (1)

- A. CH_4 - AX_4 - sp^3
B. ✓ **H_2O - AX_2E_2 - sp^2**
C. CO_2 - AX_2 - sp
D. BeCl_2 - AX_2 - sp

Answer: B

The question asks for the wrong match. Water has two bonding pairs and two lone pairs, so it is AX_2E_2 with four electron groups around oxygen, and four groups need four hybrid orbitals, which is sp^3 . The paper prints sp^2 , so option B is the mismatch. Option A is tempting to check twice, but CH_4 with AX_4 and sp^3 is correct, so it is not the answer.

16. Given the following polyatomic and diatomic molecules: CH_4 , NH_3 , H_2S , CH_4 , OF_2 , NF_3 , H_2O , CO_2 , N_2 , HF , HBr . Which one of the following sets of molecules describes the correct intermolecular force of attraction? (1)
- A. ✓ CH_4 , CCl_4 , N_2 , CO_2 - London force
B. CO_2 , H_2O , HF , NF_3 - Hydrogen bonding
C. H_2S , CCl_4 , NF_3 , HBr , N_2 - Dipole-dipole force
D. H_2S , NF_3 , CCl_4 , HBr , N_2 - Dipole-dipole force

Answer: A

CH_4 , CCl_4 , N_2 and CO_2 are all symmetrical, so any bond dipoles they have point in directions that cancel and the molecules end up nonpolar. Nonpolar molecules attract each other only through London dispersion forces, which come from momentary shifts in the electron cloud. Option B is the tempting one because H_2O and HF really do hydrogen bond, but CO_2 and NF_3 have no hydrogen attached to N, O or F, so the set as a whole is wrong.

17. Which of the following molecule contains two pi bonds and two sigma bonds ONLY? (1)
- A. CO
B. CH_4
C. ✓ HCN
D. HO

Answer: C

In HCN the hydrogen is joined to carbon by a single bond, which is one sigma bond, and carbon is joined to nitrogen by a triple bond, which is one sigma plus two pi. That totals two sigma bonds and two pi bonds. Option A is the close one, since CO also has two pi bonds, but it has only one sigma bond because there is no third atom attached.

18. Which of the following compound would have the same electrolysis of water? (1)
- A. Concentrated NaCl (aq)
B. ✓ Diluted HCl (aq)
C. Molten Al_2O_3
D. Concentrated NaCl

Answer: B

Electrolysing dilute hydrochloric acid gives hydrogen at the cathode and oxygen at the anode. The chloride is too dilute to compete, so water is oxidised instead of chloride, and the overall change is the decomposition of water into H_2 and O_2 . Option A is the tempting one, but concentrated sodium chloride solution releases chlorine at the anode, which is the chlor-alkali process and not the electrolysis of water.

19. The pressure of a gas in a cylinder when heated to a temperature of 250 K is 1.5 atm. What is the initial temperature of the gas if its initial pressure was 1.0 atm? (1)
- A. ✓ 166.67 K
B. 300 K
C. 200 K
D. 100 K

Answer: A

The volume is fixed, so pressure and temperature follow $P_1/T_1 = P_2/T_2$. Rearranging gives $T_1 = P_1 T_2 / P_2 = (1.0 \times 250) / 1.5 = 166.67$ K. Option B is the tempting one, but the gas was heated up to 250 K, so its starting temperature has to be lower than 250 K, and 300 K is higher.

20. The correct increasing order of rate of diffusion of gases PH_3 , O_2 , CH_4 , NH_3 , HCl is: (1)
- A. $\text{O}_2 < \text{HCl} < \text{PH}_3 < \text{NH}_3 < \text{CH}_4$
B. $\text{CH}_4 < \text{NH}_3 < \text{PH}_3 < \text{O}_2 < \text{CH}_4$
C. ✓ $\text{HCl} < \text{PH}_3 < \text{O}_2 < \text{NH}_3 < \text{CH}_4$
D. $\text{PH}_3 < \text{CH}_4 < \text{NH}_3 < \text{HCl} < \text{O}_2$

Answer: C

Graham's law says the rate of diffusion goes as $1/\sqrt{M}$, so the heavier the gas the slower it spreads. The molar masses here are HCl 36.5, PH_3 34, O_2 32, NH_3 17 and CH_4 16. Ordering from heaviest to lightest gives increasing rate: $\text{HCl} < \text{PH}_3 < \text{O}_2 < \text{NH}_3 < \text{CH}_4$, which is option C. Option D is the tempting one because it also runs across all five gases, but it places HCl and O_2 at the fast end when they are the two heaviest in the list.

21. Which of the following statements is TRUE about alkanes and alkenes? (1)
- A. Alkanes are unsaturated hydrocarbons, while alkenes are saturated hydrocarbons.
 - B. Alkanes and alkenes are both saturated hydrocarbons.
 - C. ✓ **Alkanes are saturated hydrocarbons, while alkenes are unsaturated hydrocarbons.**
 - D. Alkanes and alkenes are both unsaturated hydrocarbons.

Answer: C

Saturated means every carbon to carbon bond is a single bond, so the molecule already holds as many hydrogen atoms as it can. Alkanes fit that description. Alkenes contain at least one $C = C$ double bond, which leaves room for atoms to add across it, so they are unsaturated. Option A is the trap because it uses the right two words in the wrong places, giving the definitions the wrong way round.

22. How does the kinetic energy of gas particles compare to that of liquid and solid particles? (1)
- A. Gas particles have the least kinetic energy
 - B. ✓ **Gas particles have the most kinetic energy**
 - C. Gas particles have the same kinetic energy as solids
 - D. Gas particles have no kinetic energy

Answer: B

A substance has to take in energy to melt and take in more to boil, so for the same substance the gas state holds the greatest average kinetic energy of the three. That energy is what lets gas particles break away from each other and fill any container, while liquid particles slide past one another and solid particles only vibrate about fixed positions. Option C is the tempting one if you assume all particles move alike, but solid particles are locked in a lattice and carry far less energy than gas particles of the same substance.

23. Which of the following precondition of the reaction is necessarily important? (1)
- A. ✓ **Proper orientation**
 - B. High activation energy
 - C. Ineffective collision
 - D. Minimum pressure

Answer: A

Collision theory says a collision only produces a reaction when two conditions are both met: the particles must carry at least the activation energy, and they must meet in the correct orientation so that the bonds which need to break and form are facing each other. Proper orientation is the condition listed here. Option B is the tempting one because activation energy is part of the story, but a high activation energy makes reaction harder, not more likely, so it cannot be a precondition for success.

24. For the chemical reaction $H_2 + Br_2 \rightarrow 2HBr$, what can be said of the relative rates of consumption of the reactants when compared to the formation of product? (1)
- A. HBr will be produced at half the rate that bromine is consumed.
 - B. HBr will be produced at the same rate that bromine is consumed.
 - C. Br_2 and H_2 will be consumed at different rates.
 - D. ✓ **HBr will be produced at twice the rate that bromine is consumed.**

Answer: D

Read the coefficients of $H_2 + Br_2 \rightarrow 2HBr$. One mole of bromine used up makes two moles of hydrogen bromide, so HBr appears at twice the rate that Br_2 disappears. Option A is the tempting one because it uses the same factor of two, but it puts the two on the wrong side and halves the rate instead of doubling it.

25. Why does powdered zinc react faster with hydrochloric acid than a solid block?

(1)

- A. Powdered zinc has lower energy
- B. ✓ **Powdered zinc has a higher surface area for collision**
- C. The solid block has more atoms
- D. Solid blocks dissolve faster

Answer: B

Grinding zinc into powder does not change how many zinc atoms there are, but it exposes far more of them at the surface where acid can reach them. More exposed atoms means more collisions between acid particles and zinc every second, so the reaction goes faster. Option C is the tempting one, but the same mass of zinc holds the same number of atoms whether it is a block or a powder; what changes is how much of that zinc the acid can touch.

26. Which of the following is TRUE regarding the concentration of products, for a chemical reaction that is already at equilibrium, assuming no disruptions to the equilibrium?

- A. The concentrations of product and reactant are equal
- B. ✓ **The rate of forward and backward reaction are equal at equilibrium**
- C. The rate of forward and backward reaction are constant but may not be equal
- D. The concentrations of products will change continually because of reversibility.

Answer: B

At equilibrium the forward and reverse reactions have not stopped, they are running at the same rate, so every product molecule formed is matched by one turning back. That is why the measured concentrations hold steady. Option A is the tempting one, but equal rates are not equal concentrations. The value of K_c decides the ratio of products to reactants, and it is almost never one.

27. If the reaction quotient Q_c has a smaller value than the related equilibrium constant, K_c :

(1)

- A. The reaction is at equilibrium.
- B. ✓ **The reaction is not at equilibrium, and will make more products at the expense of reactants.**
- C. The reaction is not at equilibrium, and will make more reactants at the expense of products.
- D. The value of K_c will decrease until it is equal to Q_c

Answer: B

The reaction quotient Q_c is worked out the same way as K_c but from whatever concentrations you have at that moment. If $Q_c < K_c$ there are too few products compared with the equilibrium mixture, so the net reaction runs forward, making products from reactants until Q_c has climbed to K_c . Option D is the tempting one, but K_c is fixed for a given reaction at a given temperature. The mixture moves to meet K_c , not the other way round.

28. What does Le Chatelier's principle state about equilibrium?

(1)

- A. A system at equilibrium will always remain unchanged at any condition
- B. ✓ **If a system at equilibrium is disturbed, it will shift to oppose the disturbance.**
- C. Equilibrium is only affected by temperature changes.
- D. The addition of a catalyst will change the equilibrium position

Answer: B

Le Chatelier's principle says that when a system at equilibrium is disturbed by a change in concentration, pressure or temperature, it shifts in the direction that partly cancels that change. Add a reactant and it makes more product; heat an exothermic reaction and it runs backwards. Option D is the tempting one, but a catalyst speeds the forward and reverse reactions by the same factor. Equilibrium arrives sooner and sits in exactly the same place.

29. For the reaction $\text{CO(g)} + \text{H}_2\text{O(l)} \rightleftharpoons \text{CO}_2\text{(g)} + \text{H}_2\text{(g)}$, how does adding CO_2 affect equilibrium? (1)
- A. The reaction shifts toward products
B. ✓ **The reaction shifts toward the reactants**
C. No change occurs
D. The reaction stops

Answer: B

Carbon dioxide is on the product side. Adding more of it makes Q_c larger than K_c , so the system responds by using up the extra CO_2 , which means the reaction shifts back toward CO and H_2O . Option A is the tempting one because it feels as though adding something should push in that direction, but a system always shifts away from the side you added to, not toward it.

30. Which of the following cause the greatest shift in equilibrium to the left for the hypothetical reaction given: $\text{A(g)} \rightleftharpoons \text{B(g)} + \text{C(g)}$. (1)
- A. ✓ **Increases pressure**
B. Adding catalyst
C. Decrease temperature
D. Adding more PCl_5

Answer: A

Count the gas molecules on each side of $\text{A(g)} \rightleftharpoons \text{B(g)} + \text{C(g)}$: one on the left and two on the right. Raising the pressure makes the system move to the side with fewer gas molecules so that the pressure is partly relieved, and that side is the left. Option C is the tempting one, but a shift on cooling depends on which direction is exothermic, and the question never tells us that, so it cannot be the reliable answer.

31. Which of the following correctly defines alcohol? (1)
- A. hydrocarbon containing an oxygen atom
B. ✓ **A compound containing a hydroxyl (-OH) group attached to a carbon atom**
C. A compound with an oxygen atom bonded to two alkyl groups
D. A compound containing carbonyl (-C=O) group

Answer: B

An alcohol is defined by its functional group: a hydroxyl group, -OH , bonded directly to a carbon atom, as in $\text{CH}_3\text{CH}_2\text{OH}$. Option C is the tempting one because it also puts oxygen in the middle, but an oxygen bonded to two alkyl groups with no hydrogen on it, R-O-R , is an ether, and ethers behave nothing like alcohols.

32. Alcohols A, B and C all have the composition $\text{C}_4\text{H}_{10}\text{O}$. Molecules of alcohol A can be oxidized to an aldehyde; (1)
molecules of alcohol B can be oxidized to a ketone; and molecules of alcohol C can be oxidized to neither an aldehyde nor a ketone. What are the correct structural formulas of molecules A, B, and C respectively?
- A. ✓ **A: 1-butanol, B: 2-butanol, C: 2-methyl-2-propanol**
B. A: 2-butanol, B: 1-butanol, C: ether
C. A: 3-butanol, B: 2-butanol, C: 1-butanol
D. A: 2-methylbutanol, B: 2-butanol, C: ether

Answer: A

Oxidation of an alcohol needs a hydrogen atom on the carbon that carries the -OH . A primary alcohol has two such hydrogens and goes to an aldehyde, a secondary alcohol has one and goes to a ketone, and a tertiary alcohol has none, so it gives neither. Among the $\text{C}_4\text{H}_{10}\text{O}$ alcohols, 1-butanol is primary and is A, 2-butanol is secondary and is B, and 2-methyl-2-propanol is tertiary and is C. Option B in the answer list is the tempting one, but it swaps 1-butanol and 2-butanol and then names an ether, which is not an alcohol at all.

33. Which one of the following about alcohol is NOT true? (1)
- A. Dihydric and trihydric alcohols have higher boiling points than monohydric alcohols of similar molecular size
 - B. ✓ **The solubility of alcohols in water increases with increasing carbon number.**
 - C. The water solubility of dihydric and trihydric alcohols are higher than those of monohydric alcohols of similar molecular mass.
 - D. The boiling point of a branched isomer is lower than that of its isomeric straight-chain alcohol.

Answer: B

The question asks which statement is false. An alcohol dissolves in water because its $-OH$ group hydrogen bonds with water, while its carbon chain does not mix. As the chain grows the non-mixing part takes over, so solubility falls: methanol and ethanol mix with water in any ratio, but 1-pentanol is only slightly soluble. Statement B claims the opposite, so it is the answer. Option D is tempting to pick as well, but branching really does lower boiling point, so D is a true statement.

34. Which of the following is NOT a physical property of saturated monocarboxylic acids? (1)
- A. High boiling point
 - B. ✓ **Weakest intermolecular force**
 - C. Soluble in water (lower members)
 - D. Oily or waxy nature (higher members)

Answer: B

The question asks which one is not a property of these acids. A carboxylic acid molecule can hydrogen bond twice at once, through the $C=O$ and through the $O-H$, so two molecules lock together as a dimer. Those are among the strongest intermolecular forces in organic chemistry, so calling them the weakest, as option B does, is false and B is the answer. Option A is the tempting distractor, but the high boiling point is a direct result of that strong dimer bonding, so A is true.

35. The statement accurately describes the chemical composition of fats? (1)
- A. ✓ **Esters of glycerol with three saturated fatty acids**
 - B. Esters of glycerol with one saturated fatty acids.
 - C. Esters of glycerol with three unsaturated fatty acids.
 - D. Esters of glycerol with two fatty acids

Answer: A

A fat is a triester of glycerol. Glycerol has three $-OH$ groups, and in a fat all three are esterified with fatty acid chains that are mostly saturated, meaning no $C=C$ double bonds. The straight saturated chains pack together well, which is why fats are solid at room temperature. Option C is the tempting one, but three unsaturated chains describes an oil, whose kinked chains cannot pack tightly and so stay liquid.

36. Given the following set of compounds, alcohol and carboxylic acids. Select which one is correctly arranged in increasing order of their boiling points. (Compounds: $CH_3CH_2CH_2CH_2OH$, $CH_3CH(CH_3)CH_3$, $CH_3(CH_2)_5COOH$, $CH_3C(CH_3)_2COOH$) (1)
- A. $CH_3C(CH_3)_2COOH < CH_3CH_2CH_2CH_2OH < CH_3(CH_2)_5COOH < CH_3CH(CH_3)CH_3$
 - B. $CH_3(CH_2)_5COOH < CH_3CH(CH_3)CH_3 < CH_3C(CH_3)_2COOH < CH_3CH_2CH_2CH_2OH$
 - C. $CH_3CH(CH_3)CH_3 < CH_3CH_2CH_2CH_2OH < CH_3(CH_2)_5COOH < CH_3C(CH_3)_2COOH$
 - D. ✓ **$CH_3CH(CH_3)CH_3 < CH_3CH_2CH_2CH_2OH < CH_3C(CH_3)_2COOH < CH_3(CH_2)_5COOH$**

Answer: D

Rank by intermolecular force first. $CH_3CH(CH_3)CH_3$ is an alkane with London forces only, so it boils lowest. $CH_3CH_2CH_2CH_2OH$ is an alcohol and hydrogen bonds once per molecule, so it comes next. The two carboxylic acids pair up as hydrogen bonded dimers and boil highest. Between them, $CH_3C(CH_3)_2COOH$ has five carbons and is branched, so it has less surface contact than the straight seven carbon $CH_3(CH_2)_5COOH$ and boils lower. Option C is the tempting one, but it puts the long straight acid below the short branched one.

37. Which of the following is correct about the discovery of subatomic particles? (1)
- A. The experiment of nucleus discovery is cathode ray experiment
 - B. Neutron is discovered by J.J. Thomson
 - C. ✓ **Nucleus is discovered by alpha particle scattering experiment**
 - D. Proton is discovered by discharge tube experiment

Answer: C

Rutherford fired alpha particles at a very thin gold foil. Most went straight through, but a few bounced back at large angles, which can only happen if the atom's positive charge and nearly all its mass are packed into a tiny centre. That is how the nucleus was found. Option A is the tempting one, but the cathode ray experiment was Thomson's and it found the electron, not the nucleus.

38. An element has three isotopes: Isotope 1: mass = 10 amu, abundance = 2%; Isotope 2: mass = 20 amu, abundance = 95%; Isotope 3: mass = 30 amu, abundance = 3%. Which of the following is the most likely atomic mass for this element without any calculation? (1)
- A. About 23.00 amu, because it is the average mass of the isotopes.
 - B. ✓ **About 20.00 amu, because the heaviest isotope is the most abundant.**
 - C. About 25.00 amu, because it's the median mass of the isotopes.
 - D. About 10.00 amu, because the lightest isotope is the least abundant.

Answer: B

An atomic mass is a weighted average, so each isotope counts in proportion to how common it is. Here 95 atoms out of every 100 have mass 20, so the average has to sit very close to 20 amu; the 2% at 10 amu pulls down a little and the 3% at 30 amu pushes up a little, and the two nearly cancel. Option A is the tempting one because it uses the word average, but an average that ignores abundance treats the rare 30 amu isotope as though it were as common as the 20 amu one, and it lands nowhere near the true value.

39. How does atomic radius change as you move down a group in the periodic table, and why? (1)
- A. It decreases due to stronger nuclear attraction.
 - B. It remains constant because electron shielding has no effect.
 - C. ✓ **It increases due to addition of more electron shells.**
 - D. It decreases because valence electrons experience more attraction from the nucleus.

Answer: C

Going down a group, each element adds one more occupied electron shell, so the outermost electrons start out further from the nucleus. The filled inner shells also screen those outer electrons from the nuclear charge, so the pull they feel does not grow much. The result is that the atomic radius increases down a group. Option A is the tempting one because the nuclear charge really does rise going down, but the extra shell and the extra shielding outweigh it.

40. Which of the following statements is true about nonpolar covalent molecules? (1)
- A. They share electrons unequally
 - B. They are always asymmetrical
 - C. They dissolve easily in water.
 - D. ✓ **They have equal sharing of electrons.**

Answer: D

A covalent bond is nonpolar when the two atoms have the same or almost the same electronegativity, as in H_2 , Cl_2 or N_2 . Neither atom pulls the shared pair harder, so the electrons sit midway and neither end carries a partial charge. Option A is the tempting one, but unequal sharing is what makes a bond polar, which is the opposite of what the question asks.

41. A student needs to determine which compound has the highest boiling point from the given compounds: H_2S , CO_2 , NH_3 , or CH_4 . Based on your understanding of intermolecular forces, which option would you recommend and why? (1)
- A. H_2S , because it has the weakest London dispersion forces.
 - B. CO_2 , because it has dipole-dipole interactions.
 - C. ✓ **NH_3 , because it forms strong hydrogen bonds.**
 - D. CH_4 , because it has stronger dipole-dipole forces.

Answer: C

Boiling point is set by the strength of the forces between molecules. NH_3 has hydrogen bonded directly to nitrogen, so its molecules hydrogen bond to each other, and hydrogen bonding is the strongest of the forces available to these four. That takes the most energy to break, so ammonia boils highest. Option B is the tempting one, but CO_2 is linear and its two bond dipoles cancel, so it is nonpolar and has no dipole to dipole attraction at all.

42. What does the Law of Conservation of Mass state? (1)
- A. Matter can be created and destroyed in a chemical reaction.
 - B. ✓ **The total mass of reactants and products are equal in a balanced chemical reaction.**
 - C. The composition of a compound varies depending on how it is prepared.
 - D. The ratio of elements in a compound changes based on reaction conditions.

Answer: B

In a chemical reaction the atoms are only rearranged; none are created and none are destroyed. So the total mass of the reactants equals the total mass of the products, which is why every chemical equation has to be balanced. Option A is the tempting one because a reaction can look as though mass has vanished, for example when a gas escapes an open beaker, but weigh the gas too and the mass is unchanged.

43. A student performs a reaction with two reactants and finds that the actual yield is significantly lower than expected. Which approach would best help them determine whether a reactant was limiting or in excess? (1)
- A. ✓ **Calculate the theoretical yield based on stoichiometry and compare it with the actual yield.**
 - B. Measure the temperature change of the reaction to assess reactant consumption
 - C. Weigh only one reactant before and after the reaction and assume the other is limiting.
 - D. Estimate the product yield visually to determine whether the reaction reached completion.

Answer: A

Take each reactant in turn and use the balanced equation to work out how much product that amount alone could make. The reactant that gives the smaller answer runs out first, so it is the limiting one, and the smaller answer is the theoretical yield. Comparing that with the actual yield then tells you the percent yield. Option C is the tempting one because it involves weighing, but assuming which reactant is limiting is the very thing you were asked to find out.

44. What is meant by an amphoteric species? (1)
- A. ✓ **A species that can donate a proton (acid) or accept a proton (base).**
 - B. A species that can only donate a proton
 - C. A species that can only accept a proton
 - D. A species that cannot donate or accept a proton.

Answer: A

Amphoteric means a species can act as an acid in one reaction and as a base in another, giving a proton away or taking one on. Water is the standard example: it hands a proton to ammonia and takes one from hydrochloric acid. The hydrogen carbonate ion behaves the same way. Option B is the tempting one, but it names only half of the behaviour, and a species that can only donate a proton is an ordinary acid.

45. In the reaction: $\text{CH}_3\text{COOH} + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{COO}^- + \text{H}_3\text{O}^+$, what is the acid-base conjugate pair involving the reaction? (1)
- A. HCOOH and CH_3COO^- B. CH_3COOH and H_3O^+
C. CH_3COO^- and H_2O D. ✓ **H_2O and H_3O^+**

Answer: D

A conjugate acid and base differ by exactly one proton. On the right of this equation H_3O^+ is what water became after taking a proton, so H_2O and H_3O^+ are a conjugate pair, with water as the base and the hydronium ion as its conjugate acid. The other pair in the same equation is CH_3COOH and CH_3COO^- . Option B is the tempting one because both species do appear in the equation, but CH_3COOH and H_3O^+ are both acids and they sit on opposite sides, so they are not a pair.

46. A solution has a hydroxide ion concentration of $[\text{OH}^-] = 2.5 \times 10^{-3} \text{ M}$. Using $K_w = 1.0 \times 10^{-14}$, how would you determine the hydronium ion concentration $[\text{H}_3\text{O}^+]$ at 25°C ? (1)
- A. ✓ **$[\text{H}_3\text{O}^+] = (1.0 \times 10^{-14}) / (2.5 \times 10^{-3})$** B. $[\text{H}_3\text{O}^+] = (2.5 \times 10^{-3}) \times (1.0 \times 10^{-14})$
C. $[\text{H}_3\text{O}^+] = (1.0 \times 10^{-14}) + (2.5 \times 10^{-3})$ D. $[\text{H}_3\text{O}^+] = (1.0 \times 10^{-14}) - (2.5 \times 10^{-3})$

Answer: A

In any water solution at 25°C the two ion concentrations multiply to a fixed number: $[\text{H}_3\text{O}^+][\text{OH}^-] = K_w = 1.0 \times 10^{-14}$. To get the hydronium concentration you divide K_w by the hydroxide concentration, giving $[\text{H}_3\text{O}^+] = (1.0 \times 10^{-14}) / (2.5 \times 10^{-3})$, which comes to about $4.0 \times 10^{-12} \text{ M}$. Option B is the tempting one, but multiplying the two would give K_w itself, not one of the concentrations.

47. If a 0.05 M solution of $\text{Ba}(\text{OH})_2$ completely dissociates in water, what is the $[\text{OH}^-]$ and pH? (1)
- A. $[\text{OH}^-] = 0.05 \text{ M}$, $\text{pH} = 2$ B. ✓ **$[\text{OH}^-] = 0.10 \text{ M}$, $\text{pH} = 13$**
C. $[\text{OH}^-] = 0.025 \text{ M}$, $\text{pH} = 1.6$ D. $[\text{OH}^-] = 0.01 \text{ M}$, $\text{pH} = 2$

Answer: B

Each formula unit of $\text{Ba}(\text{OH})_2$ releases two hydroxide ions, so $[\text{OH}^-] = 2 \times 0.05 = 0.10 \text{ M}$. Then $\text{pOH} = -\log(0.10) = 1$, and $\text{pH} = 14 - \text{pOH} = 13$. A pH of 13 is what you expect for a fairly concentrated strong base. Option C is the tempting one, but it halves the concentration when the two hydroxide ions per formula unit mean you should double it.

48. Two students argue about the hydroxide ion concentration in a solution with a pH of 4. Student A suggested $[\text{OH}^-] = 1.0 \times 10^{-10} \text{ M}$, while Student B suggested $[\text{OH}^-] = 1.0 \times 10^{-4} \text{ M}$. Who is correct? (1)
- A. ✓ **Student A, because $\text{pOH} = 14 - \text{pH}$ and $[\text{OH}^-] = 10^{-\text{pOH}}$**
B. Student B, because in acidic solutions $[\text{OH}^-]$ is greater than $[\text{H}^+]$
C. Neither, because $[\text{OH}^-]$ can't be calculated from pH
D. Both are correct because pH and pOH are independent values.

Answer: A

At 25°C , $\text{pH} + \text{pOH} = 14$, so a pH of 4 gives $\text{pOH} = 14 - 4 = 10$ and $[\text{OH}^-] = 10^{-10} \text{ M}$. Student A is right. Student B's answer is the tempting one because 10^{-4} reuses the number from the pH, but pH 4 means the solution is acidic, so the hydroxide concentration must be far smaller than the hydrogen ion concentration, not equal to it.

49. Which of the following is the Net Effect for addition of sodium acetate (CH_3COONa) to acetic acid (CH_3COOH) solution? (1)

- A. $[\text{H}_3\text{O}^+]$ increase
B. ✓ $[\text{OH}^-]$ increase
C. pH decrease
D. ionization level of CH_3COOH increase

Answer: B

Sodium acetate dissolves to give acetate ions, which are already a product of the acid's ionisation $\text{CH}_3\text{COOH} + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{COO}^- + \text{H}_3\text{O}^+$. The extra acetate pushes that equilibrium back to the left, so less acid ionises and $[\text{H}_3\text{O}^+]$ falls. Because $[\text{H}_3\text{O}^+][\text{OH}^-]$ must stay equal to K_w , a smaller $[\text{H}_3\text{O}^+]$ means a larger $[\text{OH}^-]$. Option C is the tempting one, but with less hydronium in solution the pH rises, it does not fall.

50. Which of the following is an example of a common buffer system? (1)

- A. NaCl and HCl
B. ✓ H_2CO_3 and HCO_3^-
C. H_2SO_4 and SO_4^{2-}
D. NaOH and H_2O

Answer: B

A buffer is a weak acid together with its conjugate base. Carbonic acid, H_2CO_3 , is weak, and HCO_3^- is what is left after it loses one proton, so the pair holds a reserve that can take up added acid and added base. Option A is the tempting one because it also pairs an acid with a salt, but HCl is a strong acid that ionises completely and Cl^- is too weak a base to take a proton back, so nothing about that mixture resists a pH change.

51. What is the primary function of a buffer solution? (1)

- A. To speed up chemical reactions
B. To completely neutralize acid and base
C. ✓ To resist pH changes when acids or bases are added
D. To prevent neutralization reaction

Answer: C

A buffer holds pH nearly steady when small amounts of acid or base are added. The weak acid in the mixture reacts with any added OH^- and the conjugate base reacts with any added H_3O^+ , so the free ion concentrations barely move. Option B is the tempting one, but a buffer does not aim for complete neutralisation. It absorbs a limited amount of either and keeps the pH close to the acid's pK_a .

52. If you mix acetic acid (CH_3COOH) with sodium acetate (CH_3COONa), what will be the resulting solution? (1)

- A. A strong acid solution
B. A strong base solution
C. A neutral solution
D. ✓ A buffer solution

Answer: D

Acetic acid is a weak acid and sodium acetate supplies its conjugate base, the acetate ion. Mixing the two gives a solution holding both halves of the pair, which is the definition of a buffer, so it resists a change in pH when acid or base is added. Option A is the tempting one, but acetic acid on its own is weak and only slightly ionised, and the added acetate suppresses even that, so the mixture is nothing like a strong acid solution.

53. Which of the following is the correct difference between soap and detergent?

(1)

- A. Soap is better than detergent
- B. Soap is made from synthetic fats or oils, while detergents are natural.
- C. ✓ **Soaps do not work well in hard water, but detergents work better in hard water.**
- D. Both soap and detergent are equally dissolve in water

Answer: C

Soap is the sodium salt of a long chain fatty acid. Hard water carries Ca^{2+} and Mg^{2+} , and these form an insoluble scum with the fatty acid ends, so the soap is wasted before it can clean. A detergent's sulfonate head forms calcium and magnesium salts that stay dissolved, so it still lathers in hard water. Option B is the tempting one, but it reverses the origins: soaps are made from natural fats and oils, and detergents are the synthetic ones.

54. If a buffer solution has a pH of 7.4 and additional small amount of HCl is added, what will likely happen?

(1)

- A. ✓ **The pH will decrease slightly**
- B. The pH will increase significantly
- C. The buffer will break down immediately
- D. The pH will remain exactly the same

Answer: A

Adding a small amount of HCl puts extra H_3O^+ into the solution, and the conjugate base in the buffer takes most of it up. Some hydronium is left over, so the pH drops, but only a little instead of plunging the way it would in unbuffered water. Option D is the tempting one, but it goes too far. A buffer reduces the change; it cannot remove it completely.

55. Why is the bicarbonate buffer system essential in human blood?

(1)

- A. It neutralizes strong acids only
- B. ✓ **It maintains blood pH within a narrow pH range**
- C. It increases oxygen levels in the blood
- D. It eliminates carbon dioxide

Answer: B

Blood is held near pH 7.4 by the H_2CO_3 and HCO_3^- pair. Acid produced by working muscles is taken up by the bicarbonate ion, and any excess base is neutralised by the carbonic acid, while the lungs and the kidneys adjust CO_2 and HCO_3^- to keep the pair topped up. Enzymes stop working if the pH moves far from this range. Option A is the tempting one, but the system takes up added base in the same way it takes up added acid, so limiting it to acids only misses half of what it does.

56. Consider potassium phosphate (K_3PO_4) dissolving in water. Why does the solution become basic?

(1)

- A. ✓ **The phosphate ion (from a weak acid) hydrolyzes to produce OH^- ions.**
- B. The potassium ion hydrolyzes to produce OH^- ions.
- C. Both ions hydrolyze equally to raise the pH.
- D. Neither ion hydrolyzes.

Answer: A

K_3PO_4 dissolves into K^+ and PO_4^{3-} . Phosphate is the conjugate base of the weak acid HPO_4^{2-} , so it is strong enough to pull a proton off water: $PO_4^{3-} + H_2O \rightleftharpoons HPO_4^{2-} + OH^-$. The hydroxide ions this produces make the solution basic. Option B is the tempting one, but K^+ comes from the strong base KOH , and the cation of a strong base does not react with water at all.

57. A chemist is examining the titration curve of a reaction between an acid and a base. By analyzing the curve, the chemist notices that after a certain volume of titrant has been added, the neutralization reaction is nearly complete. Based on your analysis of the titration data, which statement best defines the equivalence point? (1)

- A. ✓ **Amount of titrant = Amount of analyte in a sample.**
B. Amount of titrant > Amount of analyte in a sample.
C. Amount of titrant < Amount of analyte in a sample.
D. Neither of titrant nor analyte consumed

Answer: A

The equivalence point is the moment when the moles of titrant added exactly match the moles of analyte in the flask, in the ratio the balanced equation demands. It is a stoichiometric statement, and it does not always fall at pH 7. Option B is the tempting one because the pH keeps climbing after that point, but once the titrant is in excess you have moved past equivalence, so the excess describes the region after the point rather than the point itself.

58. Which of the following is correct about oxidation-reduction reaction? (1)

- A. ✓ **Oxidation reaction takes place by losing of electron**
B. Electron is always transferred from oxidizing agent to reducing agent
C. Reduction takes place by increasing its oxidation number
D. The reaction takes place without transferring of electron.

Answer: A

Oxidation is loss of electrons and reduction is gain, which is what the memory aid OIL RIG stands for. Losing negative charge makes an atom's oxidation number go up, so oxidation and a rise in oxidation number always travel together. Option C is the tempting one because it names an increase in oxidation number, which is real chemistry, but it attaches that increase to reduction. Reduction lowers the oxidation number.

59. Which of the following is TRUE about metallic conductors? (1)

- A. There is flow of electrical energy and transfer of matter
B. Electrical conduction through metals does bring about chemical transformations
C. ✓ **Free and mobile electrons of the metallic atoms are responsible for electrical conductance**
D. Conductivity of metal increases with increase in temperature

Answer: C

In a metal the valence electrons leave their atoms and form a shared sea around fixed positive ions. Apply a voltage and those delocalised electrons drift through the lattice, carrying the current while the metal itself stays chemically unchanged. Option D is the tempting one, but heating makes the metal ions vibrate harder and scatter the moving electrons, so a metal's conductivity falls as temperature rises.

60. For the electrolysis of aqueous copper(II) sulfate, which of the following statements is correct? (1)

- A. Cu and O₂ are produced in mol ratio of 1:1
B. H₂ and O₂ are produced in mol ratio of 1:1
C. H₂ and O₂ are produced in mol ratio of 2:1
D. ✓ **Cu and O₂ are produced in mol ratio of 2:1**

Answer: D

Write both electrode reactions. At the cathode $Cu^{2+} + 2e^- \rightarrow Cu$, and at the anode water is oxidised because sulfate is not, giving $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$. Every 4 moles of electrons therefore deposit 2 moles of copper and release 1 mole of oxygen, a ratio of 2 to 1. Option A is the tempting one, but a 1 to 1 ratio ignores that copper needs 2 electrons per atom while oxygen needs 4 per molecule.

61. What is Faraday's first law of electrolysis?

(1)

- A. The amount of substance deposited is directly proportional to the voltage
- B. The amount of substance deposited is inversely proportional to the time taken
- C. The amount of substance deposited is inversely proportional to the charge
- D. ✓ **Amount of substance deposited is directly proportional to the charge passed through the cell**

Answer: D

Faraday's first law states that the mass of a substance deposited or liberated at an electrode is directly proportional to the quantity of electric charge passed through the cell, with $Q = It$. Double the charge and you double the mass. Option A is the tempting one because a battery's voltage does affect how fast charge flows, but the law itself is written in terms of the charge that actually passes, not the voltage that pushed it.

62. The process of electro refining of copper involves electrolysis. What is the primary purpose of this process in industry?

(1)

- A. To add impurities to copper
- B. To decrease the temperature of copper
- C. To make copper a better conductor
- D. ✓ **To remove impurities from copper**

Answer: D

In electro-refining, a slab of impure copper is made the anode and a thin sheet of pure copper the cathode. The anode dissolves as Cu^{2+} , those ions plate onto the cathode, and the impurities either stay dissolved or drop below the anode as sludge, which is where silver and gold are recovered from. The product is copper of about 99.99% purity. Option C is the tempting one, but better conductivity is a result of the purity, not the purpose of the process.

63. Given the challenges of corrosion in metal products, evaluate the effectiveness of electroplating in preventing rust formation compared to other protective methods used in the manufacturing industry.

(1)

- A. ✓ **Electroplating is the most effective method that forms durable protective coating on metals.**
- B. Electroplating is less effective than galvanization because it requires more maintenance.
- C. Electroplating is ineffective in preventing rust formation at extreme temperatures.
- D. Electroplating is only effective when metals are combined with nonmetals.

Answer: A

Electroplating lays down a thin continuous layer of a corrosion resistant metal such as chromium, nickel or zinc onto the iron object. That layer keeps oxygen and water away from the iron underneath, and since rusting needs both, the rusting cannot start. The coating is bonded to the metal rather than sitting on it like paint, so it survives handling. Option B is the tempting one, but galvanising is itself a zinc coating and nothing here makes an electroplated layer the higher maintenance choice.

64. Which of the following statements correctly distinguishes between primary and secondary cells?

(1)

- A. Primary cells can be recharged, while secondary cells cannot
- B. Secondary cells convert chemical energy into electrical energy only once
- C. ✓ **Primary cells are for single-use, while secondary cells can be recharged**
- D. Both types of cells are rechargeable

Answer: C

In a primary cell the reaction cannot be driven backwards, so once the reactants are used up the cell is finished and is thrown away, as with an ordinary dry cell. In a secondary cell an external current can push the reaction in reverse and rebuild the original reactants, which is what charging a lead acid or lithium ion battery does. Option A is the tempting one because it uses the same two words, but it swaps them, and a primary cell is the one that cannot be recharged.

65. In a galvanic cell, why does oxidation occur at the anode? (1)
- A. Because the anode is always negatively charged in an electrochemical cell
 - B. ✓ **Because electrons are sourced from anode and enter to cathode**
 - C. Because reduction can only happen at the cathode
 - D. Because the anode gains electrons

Answer: B

Oxidation is the loss of electrons, and the anode is by definition the electrode where those electrons are released into the external circuit. In the cell they travel from the anode through the wire to the cathode, where reduction takes place.

Option A is the tempting one, and the anode really is the negative terminal of a galvanic cell, but that sign is a consequence of the electrons gathering there, not the reason oxidation happens at that electrode. In an electrolytic cell the anode is positive and oxidation still occurs there.

66. Which of the following is best describing the difference between electrolytic and galvanic cell? (1)
- A. ✓ **Electrolytic cell: Requires an external power supply; Galvanic cell: Generates electrical energy**
 - B. Electrolytic cell: Spontaneous ($\Delta G < 0$); Galvanic cell: Non-spontaneous ($\Delta G > 0$)
 - C. Electrolytic cell: Electrons flow from cathode to anode through an external wire; Galvanic cell: Electrons flow from anode to cathode through salt bridge.
 - D. Electrolytic cell: Oxidation takes place at anode electrode; Galvanic cell: Oxidation takes place at cathode electrode

Answer: A

An electrolytic cell runs a reaction that would not happen on its own, so it needs an external power supply to push it, and $\Delta G > 0$. A galvanic cell runs a spontaneous reaction, $\Delta G < 0$, and gives out electrical energy, which is what an ordinary battery does. Option B is the tempting one because it uses the right vocabulary, but it attaches the spontaneity to the wrong cell in each case.

67. What is the primary contribution of industrial chemistry to society? (1)
- A. Reducing the need for natural resources
 - B. ✓ **Producing materials essential for daily life**
 - C. Reducing extent to use resources
 - D. Stopping all chemical reactions

Answer: B

Industrial chemistry takes raw materials such as air, brine, limestone and crude oil and turns them into the fertilisers, cement, fuels, soaps, medicines and plastics that people use every day. That conversion is its main contribution. Option A is the tempting one because efficient processes do save material, but industry consumes natural resources on a large scale rather than reducing the need for them.

68. Which of the following is a renewable resource? (1)
- A. Coal
 - B. Petroleum
 - C. ✓ **Solar energy**
 - D. Natural gas

Answer: C

Solar energy arrives continuously from the sun and is not used up by being collected, so it counts as renewable. Coal, petroleum and natural gas are all fossil fuels, formed from buried organic matter over millions of years, and we burn them far faster than any of it re-forms, so all three are non-renewable. Option A is the tempting one because coal reserves are large, but plentiful is not the same as renewable.

69. Which of the following would decrease ammonia production in the Haber process? (1)
- A. Increasing nitrogen concentration B. Removing ammonia as it is formed
C. ✓ **Increasing temperature significantly** D. Using an iron catalyst

Answer: C

The Haber reaction $N_2 + 3H_2 \rightleftharpoons 2NH_3$ gives out heat, so by Le Chatelier's principle raising the temperature shifts the equilibrium back toward nitrogen and hydrogen and lowers the yield of ammonia. Plants still run warm, near 450°C , because a low temperature would make the reaction far too slow, so the setting is a compromise. Option B is the tempting one, but taking ammonia out as it forms pulls the equilibrium forward and raises production.

70. Which of the following is NOT true about industrial production of sodium carbonate (Na_2CO_3)? (1)
- A. The raw materials are brine solution (NaCl), limestone (CaCO_3), ammonia and water
B. The byproduct of manufacturing of Na_2CO_3 in the Solvay process is CaCl_2
C. Burning coke in the Solvay process is required to provide the heat energy
D. ✓ **The Solvay process involves industrial manufacturing process of Na_2SO_4**

Answer: D

The question asks which statement is false. The Solvay process makes sodium carbonate, Na_2CO_3 , from brine, limestone, ammonia and water, and sodium sulfate is not part of it at all, so option D is the answer. Option B is the tempting one to pick because it names a byproduct, but calcium chloride really is the Solvay byproduct, which makes B a true statement and therefore not the one you want.

END OF THE MARKING KEY

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