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Answer with Explanation

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PG TRB CHEMISTRY - ANSWER KEY

1	2	3	4	5	6	7	8	9	10
B	A	D	B	C	A	B	B	A	B
11	12	13	14	15	16	17	18	19	20
B	D	C	B	A	A	A	A	B	D
21	22	23	24	25	26	27	28	29	30
B	B	B	B	B	C	A	A	A	B
31	32	33	34	35	36	37	38	39	40
D	B	A	C	B	B	C	B	B	C
41	42	43	44	45	46	47	48	49	50
A	A	A	C	C	B	D	B	C	B
51	52	53	54	55	56	57	58	59	60
C	B	A	B	B	A	A	B	A	B
61	62	63	64	65	66	67	68	69	70
D	A	B	A	A	B	C	C	A	D
71	72	73	74	75	76	77	78	79	80
C	C	D	B	A	B	B	B	B	B
81	82	83	84	85	86	87	88	89	90
D	A	C	C	B	A	C	B	A	D
91	92	93	94	95	96	97	98	99	100
D	B	C	A	B	B	B	D	B	B
101	102	103	104	105	106	107	108	109	110
D	A	C	C	C	C	B	B	A	B
111	112	113	114	115	116	117	118	119	120
C	B	B	B	A	C	C	A	B	B
121	122	123	124	125	126	127	128	129	130
C	B	B	A	B	B	B	B	A	A
131	132	133	134	135	136	137	138	139	140
B	C	A	A	C	A	A	B	A	C
141	142	143	144	145	146	147	148	149	150
C	C	D	A	B	B	D	C	B	A
151	152	153	154	155	156	157	158	159	160
D	A	B	C	B	D	B	A	B	A
161	162	163	164	165	166	167	168	169	170
D	B	C	B	B	C	C	B	A	C
171	172	173	174	175	176	177	178	179	180
B	C	C	D	C	B	A	B	A	A

PG TRB CHEMISTRY

ANSWER KEY (EXPLANATION)

31) d. $S = 10.20$, $Z_{eff} = 4.80$

Explanation:

Phosphorus:$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$, we are considering a 3p electron.
Same group (n=3), i.e., $3s^23p^3$ but exclude the electron of interest) there are 4 other electrons.
Each contributes 0.35. Contribution = $4 \times 0.35 = 1.40$.
(n – 1) shell = n=2 ($2s^2\ 2p^6$), there are 8 electrons. Each contributes 0.85.
Contribution = $8 \times 0.85 = 6.80$.
(n – 2) or lower = n=1 ($1s^2$), there are 2 electrons. Each contributes 1.00.
Contribution = $2 \times 1.00 = 2.00$.
$S = 1.40 + 6.80 + 2.00 = 10.20$. Effective charge = $Z_{eff} = Z-S = 15-10.20= 4.80$

32) b. More s-character, shorter than C–F bond

Explanation:

According to Bent's rule: The C–H bonds (toward electropositive H) will have more s-character → shorter and stronger. The C–F bond (toward electronegative F) will have more p-character → longer and weaker.

33) a. 0

Explanation:

He_2 → 4 electrons. σ_{1s} → bonding orbital → 2 electrons. σ^*_{1s} → antibonding orbital → 2 electrons.
Bond order = (Number of bonding electrons – Number of antibonding electrons)/2 = 2-2 = 0

34) c. Hard-hard interactions are stronger than hard-soft interactions.

Explanation:

Hard species: small, non-polarizable. Soft species: large, polarizable
Symbiosis principle: like reacts better with like → Hard–Hard, Soft–Soft.

35) b. Liquid ammonia

Explanation:

(NH_3) is unique because it can dissolve alkali metals and stabilize the electrons in solution. The blue colour of the solution is a visual indicator of solvated electrons.

36) b. Oxygen

Explanation:

The oxygen atom has a lone pair of electrons, which it can donate to a metal center, forming a coordinate (dative) bond. Carbon and hydrogen do not have lone pairs available for coordination, and nitrogen is not part of the alkoxide group. Example: Sodium methoxide, $NaOCH_3$, can coordinate to a metal center through the O atom.

37) c. CN^-

Explanation:

Strong σ-donor ligands and/or π-acceptor ligands usually have a high trans effect. They increase electron density at the metal, weakening the trans M–L bond. Trans effect order (common): $CN^- > CO > PR_3 > NO_2^- > I^- > Br^- > Cl^- > NH_3 > H_2O$. CN^- is a strong π-acceptor ligand, so it has the highest trans effect. NH_3 and H_2O are weak σ-donors, so low trans effect. Cl^- is moderate.

38) b. d^9

Explanation:

Electron configuration: $t_{2g}^6\ e_g^3$ → unevenly filled e_g orbital

Jahn-Teller effect strongly elongates the z-axis → Z-out distortion. d^4 low spin ($t_{2g}^4e_g^0$) – z in distortion. d^{10} ($t_{2g}^6e_g^4$): All orbitals are filled. This is a non-degenerate state, so no Jahn-Teller distortion occurs. d^5 high-spin ($t_{2g}^3e_g^2$): All five d orbitals are singly occupied. This is a half-filled, high-spin, non-degenerate state ($^6A_{1g}$), so no Jahn-Teller distortion occurs.

39) b. Gd^{3+}

Explanation:

Gd^{3+} has half-filled 4f orbitals (f^7), which is most stable and strongly paramagnetic.

La^{3+} and Lu^{3+} are diamagnetic because their 4f orbitals are either empty or filled. Ce^{3+} has one unpaired electron, it is paramagnetic, but weakly compared to ions like Gd^{3+} (which has 7 unpaired electrons).

40) c. In a dissociative interchange mechanism, bond breaking dominates over bond formation.

Explanation:

Dissociative interchange (I_d mechanism) is a concerted single step, the activation barrier is dominated by the energy required for the bond breaking to the leaving group. The formation of the new bond is secondary in importance to the breaking of the old one. In a dissociative (D) mechanism, the leaving group departs in the first step to form an intermediate with a lower coordination number (e.g., a 5-coordinate intermediate from a 6-coordinate starting material). In an associative (A) mechanism, the entering group coordinates in the first step to form an intermediate with a higher coordination number (e.g., a 7-coordinate intermediate from a 6-coordinate starting material). In an associative interchange (I_a mechanism), the entering group and leaving group are both involved in the single transition state, with bond formation dominating over bond breaking.

41) a. $^3A_{2g}$

Explanation:

The 8 electrons are placed as $t_{2g}^6e_g^{2.}$ Number of unpaired electrons (n) in the e_g orbitals is 2. Total spin (S) is $S=n\times1/2=2\times1/2=1$. Spin Multiplicity (2S+1) is $2(1)+1=3$. The ground state will be a triplet state. For an e_g^2 configuration, the possible term symbols are obtained from the direct product $e_g=A_{1g}+A_{2g}+E_g$. The possible terms are $^1A_{1g}$, $^3A_{2g}$, and ^1E_g. The term with the highest spin multiplicity is the lowest in energy. This is the triplet state, $^3A_{2g}$. Therefore, the ground term symbol for d^8 Ni^{2+} in an octahedral field is $^3A_{2g}$.

42) a. Rhodium complex

Explanation:

The Monsanto process is an industrial method for producing acetic acid from methanol (CH_3OH) and carbon monoxide (CO) under acidic conditions. The active catalyst is a rhodium complex, specifically cis-$[Rh(CO)_2I_2]^-$.

43) a. The two groups to be eliminated are cis to reach other

Explanation:

Reductive elimination is the process in which two ligands (often C–C, C–H, or C–X groups) bound to a metal center combine and leave as a new molecule, reducing the oxidation state of the metal by 2 units. For this to happen, the two ligands must be spatially close enough to form a new bond. If they are cis (adjacent) → they are close and can couple → elimination occurs easily. If they are trans (opposite sides) → too far apart → reductive elimination is unfavorable. Reductive elimination reduces the oxidation state of the metal. Therefore, it is more favorable when the metal is in a high oxidation state (since elimination stabilizes it). A low electron density metal favors reductive elimination

44) c. $[V(CO)_6]$

Explanation:

$[V(CO)_6]$ does not satisfy 18-electron rule, it has only 17 electrons. $[Fe(CO)_5]$ and $[Ni(CO)_4]$ obeys 18 electron rule and are stable. $[PtCl_4]^{2-}$ is d^8 square-planar complex and stable with 16 e^-.

45) c. 7

Explanation:

Total coordination number = 3 (terminal CO) + 3 (bridging CO) + 1(Fe–Fe bond) = 7.

46) b. Partial delocalization with alternating B–N bonds

Explanation:

Borazine ≈ planar, partially delocalized six-membered ring with alternating B–N bonds.

47) d. Quadruple bond

Explanation:

A quadruple bond is a type of chemical bond between two atoms involving eight electrons. Here there are 4 bonds between 2 Re atoms involving 8 electrons.

48) b. A–4, B–3, C–1

Explanation:

Ceruloplasmin (A) is a copper-containing protein. Function: It transports copper in the blood and acts as a ferroxidase, oxidizing $Fe^{2+} \rightarrow Fe^{3+}$ so that transferrin can bind iron. Transferrin (B) → Iron (Fe^{3+}), the main iron transport protein. Metallothionein (C) is a small, cysteine-rich protein that primarily binds zinc (Zn^{2+})

49) c. Four sulfur atoms from cysteine residues

Explanation:

Rubredoxin is a small iron–sulfur protein involved in electron transfer. Its Fe atom is coordinated tetrahedrally by four cysteine thiol (–SH) groups, forming a FeS_4 center.

50) b. Sigmoidal curve

Explanation:

Produces a sigmoidal (S-shaped) O_2-dissociation curve, unlike myoglobin, which is a monomer and shows a hyperbolic curve. The sigmoidal curve allows hemoglobin to efficiently pick up O_2 in the lungs (high O_2 concentration) and release O_2 in tissues (low O_2 concentration)

51) c. Disposal of radioactive nuclear waste

Explanation:

The primary hazard of nuclear power is related to radioactive waste management, which requires secure, long-term storage to prevent contamination

52) b. −1.192 Me

Explanation:

$Q = (\text{Mass of reactants} - \text{Mass of products}) \times c^2$,
$\Delta m = (14.003074\ u + 4.002603\ u) - (16.999132\ u + 1.007825\ u)$
$\Delta m = 18.005677\ u - 18.006957\ u = -0.001280\ u$, $Q = \Delta m \times 931.5\ \text{MeV/u}$
$Q = (-0.001280\ u) \times (931.5\ \text{MeV/u}) \approx -1.192\ \text{Me}$

53) a. (½) $\hbar\omega$

Explanation:

$\hbar\omega$ → This is the *spacing* between energy levels, ΔE, not the zero-point energy. (½) $h\omega$ → Incorrect, as $\hbar$ is the correct constant for angular frequency ω. zero → Incorrect, this is the prediction of classical mechanics. Quantum mechanics requires a non-zero minimum energy due to the Heisenberg Uncertainty Principle.

54) b. Perturbation is small compared to unperturbed Hamiltonian

Explanation:

Perturbation theory is most accurate when the perturbation is small compared to the unperturbed Hamiltonian. Perturbation theory is an approximation method where the total Hamiltonian ($\widehat{H}$) is split into an exactly solvable part ($\widehat{H}^{(0)}$) and a small correction (the perturbation, $\widehat{H}\ ^{(1)}$). Option (a) is incorrect because if the perturbation is very large, the series will diverge or converge too slowly, making the approximation poor or useless. Option (c) is incorrect; perturbation theory is a quantum mechanical method. Option (d) is incorrect; the accuracy depends on the relative strength of the perturbation, not the excitation level (though perturbation theory is often applied to the ground state).

55) b. $^{3}\Sigma g^{-}$.

Explanation:

A ground state term symbol represents the lowest energy electronic configuration of an atom or molecule, described as $^{2S+1}\Lambda_{(g/u)}$. Spin multiplicity: Two unpaired electrons → $S=1$ → multiplicity $= 2S+1=3$ → triplet, $\Lambda = 0 \rightarrow \Sigma$ term. Even number of electrons in bonding/antibonding orbitals → g (gerade). Reflection symmetry along internuclear axis: – (since antisymmetric with respect to reflection in a plane containing the bond axis). The ground state molecular term symbol for the oxygen molecule (O_2) is $^{3}\Sigma g^{-}$.

56) a. Coulomb Integral

Explanation:

In Hückel Molecular Orbital (HMO) theory, α (the Coulomb Integral H_{ii}) represents the approximate energy of an electron when it is localized solely in a single p atomic orbital on atom i, without considering the influence of neighbouring atoms.

57) a. Staggered: D_5d ; Eclipsed: D_5h

Explanation:

Staggered ferrocene → Cp rings rotated 36° → D_5d point group. Symmetry elements: C_5 axis, S_{10} improper axis, inversion center (i), No σh plane. Eclipsed ferrocene → Cp rings directly aligned → D_5h point group. Symmetry elements: C_5 axis, horizontal mirror plane (σh), 5 C_2 axes.

58) b. n → π*

Explanation:

In carbonyl compounds (C=O), the oxygen atom has lone pairs (non-bonding electrons, n). These nonbonding electrons can be excited to the π* antibonding orbital of the C=O bond. This gives the characteristic n → π* transition.

59) a. Stokes lines

Explanation:

In Raman spectroscopy, when monochromatic light interacts with molecules, most photons are scattered elastically (no energy change) → Rayleigh lines. A small fraction is scattered inelastically (energy change) → Raman lines. Stokes lines (lower energy than incident light), photon loses energy to excite the molecule to a vibrational/rotational level. Scattered photon has lower frequency (longer wavelength). Anti-Stokes lines (higher energy than incident light) photon gains energy from an already excited molecule. Scattered photon has higher frequency (shorter wavelength).

60) b. 3 and 1: 2: 1

Explanation:

The general formula for the number of lines due to hyperfine splitting: Number of lines = 2nI+1. Here n=2 (two equivalent nuclei), I=1/2, Number of ESR lines = 3. The splitting pattern is a triplet with relative intensities 1:2:1.

61) d. Density, Temperature, Pressure

Explanation:

An intensive property is a characteristic of a system that does not depend on the amount of matter present, meaning it remains the same regardless of the quantity of the substance. Pressure, temperature and density are intensive properties. Volume, enthalpy, and heat capacity are extensive properties. They depend on the mass of the system.

62) a. V

Explanation:

dG = VdP – SdT,

$$\left(\frac{\partial G}{\partial P}\right)_T = V$$

63) b. Decrease

Explanation:

$B \propto 1/I$, and $I=\mu r^2$, an increase in bond length (r) leads to an increase in moment of inertia (I), which causes the rotational constant (B) to decrease.

64) a. $n_1 d\mu_1 + n_2 d\mu_2 = 0$

Explanation:

The equation form of the Gibbs–Duhem equation for a binary mixture (components 1 and 2) at constant temperature (T) and pressure (P) is: $n_1 d\mu_1 + n_2 d\mu_2 = 0$, where

n_1 and n_2 are the number of moles of component 1 and 2. μ_1 and μ_2 are the chemical potentials (partial molar Gibbs free energy) of component 1 and 2. $d\mu_1$ and $d\mu_2$ are the changes in the chemical potentials.

65) a. Pressure

Explanation:

An ideal gas (where non-ideal behaviour corrections are unnecessary), the fugacity is exactly equal to the pressure. The ratio of the two, the fugacity coefficient ($\phi = f/P$), is exactly 1 for an ideal gas.

66) b. Indistinguishable with integer spin

Explanation:

Bose–Einstein statistics applies to particles that are indistinguishable with integer spin. These particles are known as bosons. Quantum mechanics treats particles governed by Bose–Einstein statistics as identical and indistinguishable. Bosons, such as photons, gluons, and helium-4 atoms, have a total intrinsic angular momentum (spin) that is an integer value, for example, 0, 1, or 2. Unlike particles that follow Fermi–Dirac statistics, bosons do not obey the Pauli exclusion principle. This means an unlimited number of bosons can occupy the same quantum state. This property leads to phenomena like Bose–Einstein condensation.

67) c. RMS Speed

Explanation:

$u_{\text{mp}} < u_{\text{avg}} < u_{\text{rms}}$. $u_{\text{mp}} : u_{\text{avg}} : u_{\text{rms}} \approx 1 : 1.128 : 1.224$

68) c. Acetone + $CHCl_3$

Explanation:

Acetone + $CHCl_3$ → Strong hydrogen bonding between the C=O of acetone and H–CCl_3. Stronger A–B attraction than like molecules → *negative deviation*. Acetone + CS_2 → Acetone is polar (C=O), CS_2 is non-polar. Weak interactions → *positive deviation*. Chloroethane + Bromoethane → Both similar (halogenated hydrocarbons), intermolecular forces nearly ideal → almost *no deviation*, or very small. Benzene + Toluene → Both are non-polar, very similar → nearly *ideal solution* (Raoult's law obeyed).

69) a. 0

Explanation:

F=C−P+1. For condensed systems under constant pressure, like most metallurgical diagrams, C=2 (Lead + Silver → binary system). At the eutectic point, the phases in equilibrium are: Solid Pb, Solid Ag, Liquid melt, ⇒ P=3, F = C−P+1 = 2−3+1=0.

70) d. Tyndall effect

Explanation:

Tyndall effect → *Optical property* due to scattering of light by colloidal particles. This depends on size and refractive index difference, not on charge. Coagulation → Depends on charge. Adding electrolyte neutralizes charge and causes aggregation. Electrophoresis → Motion of charged particles under an electric field. Depends directly on charge sign and magnitude. Electro-osmosis → Motion of dispersion medium under electric field, also caused by charge on colloidal particles.

71) c. $FeCl_3$ solution + 2 drops NH_4OH solution

Explanation:

A positive colloid is formed when the dispersed particles in a liquid medium have a positive charge. When $FeCl_3$ solution is added to NH_4OH solution, the Fe^{3+} ions (which have a positive charge) adsorb onto the surface of the newly formed hydroxide particles, creating a positively charged colloidal system. KI solution + 2 drops $AgNO_3$ solution: This reaction forms a precipitate of silver iodide (AgI), not a colloid. AgI is insoluble and will precipitate out of the solution. NH_4OH solution + 2 drops $FeCl_3$ solution: While this reaction involves the formation of $Fe(OH)_3$ precipitate, the Fe^{3+} ions are not the dominant charge carriers in this case. The resulting colloid, if formed, would likely be neutral or negatively charged due to the presence of excess OH^- ions from the NH_4OH solution. H_2S is passed in dilute $AsCl_3$ solution: This reaction leads to the formation of As_2S_3 precipitate, a sulfide solid, not a colloid. H_2S (hydrogen sulfide) reacts with $AsCl_3$ to produce the insoluble As_2S_3.

72) c. log (x/m) vs. log P

Explanation:

$$\frac{x}{m} = kP^{1/n}$$

$$\log\left(\frac{x}{m}\right) = \log(k) + \frac{1}{n}\log(P)$$

Therefore, a plot of (log (x/m)) on the y-axis against (log (P)) on the x-axis will yield a straight line.

73) d. MC: (E, V, N); CE: (N, V, T); GC: (V, T, μ)

Explanation:

Microcanonical ensemble specifies a system with fixed Energy (E), Volume (V), and Number of particles (N). The Canonical ensemble fixes the Number of particles (N), Volume (V), and Temperature (T) of the system in contact with a heat bath. Finally, the Grand Canonical ensemble is characterized by a fixed Volume (V), Temperature (T), and Chemical Potential (μ), allowing for the exchange of both energy and particles with a reservoir.

74) b. Incongruent

Explanation:

In the phenol–water system, melting of phenol in water is incongruent. This is because the solid phenol does not melt directly into a liquid of the same composition. Instead, the melting process involves a peritectic invariant point, where solid phenol coexists with two different liquid phases. Congruent melting would mean the solid phenol melts into a liquid of the same composition, which does not happen in this system. Sublimation is the transition from solid to gas, which is not the primary phase change occurring here. The mutual solubility and melting behaviour in the phenol–water system are highly dependent on temperature, as seen in the existence of a critical solution temperature (CST).

75) a. $k_1k_3[A]^2 / (k_3+k_2[A])$

Explanation:

The correct rate law for the formation of a product (P) according to the Lindemann-Hinshelwood mechanism is $k_1k_3[A]^2 / (k_3+k_2[A])$. This expression is derived by applying the steady-state approximation to the concentration of an activated intermediate molecule, A*.

76) b. 9 times

Explanation:

$r = k\,(p_A)^2\,(p_B)^0 = k\,(p_A)^2$,

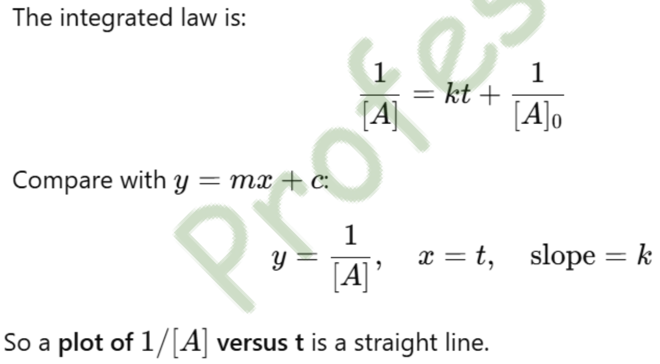
$V \rightarrow V/3$, $(p \propto 1/V) \Longrightarrow p_{new} = 3p_{old}$

Original rate: $r_{old} = k(p_A)^2$, $p_{Anew} = 3p_A$,

$r_{new} = k(3p_A)^2 = k \cdot 9(p_A)^2 = 9\,r_{old}$

77) b. a plot of $1/[A]$ versus t is a straight line

Explanation:



The integrated law is:

$$\frac{1}{[A]} = kt + \frac{1}{[A]_0}$$

Compare with $y = mx + c$:

$$y = \frac{1}{[A]}, \quad x = t, \quad \text{slope} = k$$

So a **plot of $1/[A]$ versus t** is a straight line.

78) b. is proportional to [S]

Explanation:

The Michaelis-Menten equation for the initial reaction velocity (v_0) is:

$$v_0 = \frac{V_{max}[S]}{K_m + [S]}$$

When the substrate concentration is very low, the condition is $[S] \ll K_m$
Under this condition, the [S] term in the denominator is negligible compared to K_m, so the denominator can be approximated as: $K_m + [S] \approx K_m$
Substituting this approximation back into the Michaelis-Menten equation:

$$v_0 \approx \frac{V_{\text{max}}[S]}{K_m}$$

Since V_{max} and K_m are constants for a given enzyme concentration:

$$v_0 \approx \left(\frac{V_{\text{max}}}{K_m}\right)[S]$$

This form shows that the initial rate (v_0) is directly proportional to the substrate concentration ([S]). The reaction is thus first-order with respect to the substrate.

79) b. $\log(\gamma_\pm) = -\sqrt{2}A$

Explanation:

$$\log(\gamma_\pm) = -A|z_+ z_-|\sqrt{I}$$

$$I = \frac{1}{2}\sum_i m_i z_i^2$$

$$I = \frac{1}{2}\left(m_{\text{Na}^+} z_{\text{Na}^+}^2 + m_{\text{Cl}^-} z_{\text{Cl}^-}^2\right)$$

$$I = \frac{1}{2}\left((2)(+1)^2 + (2)(-1)^2\right)$$

$$I = \frac{1}{2}(2+2) = \frac{1}{2}(4)$$

$$I = 2$$

$$\log(\gamma_\pm) = -A|z_+ z_-|\sqrt{I}$$

$$\log(\gamma_\pm) = -A(1)\sqrt{2}$$

$$\log(\gamma_\pm) = -A\sqrt{2}$$

80) b. $Pb^{2+} \rightarrow Pb^{4+}$

Explanation:

The anode is the positive terminal during charging, and the reaction involves oxidation. The lead sulfate ($PbSO_4$) on the anode is converted back into lead dioxide (PbO_2), which is the active material for the positive plate. The oxidation state of lead changes from +2 in $PbSO_4$ to +4 in PbO_2, indicating oxidation.

$$PbSO_4 + 2H_2O \rightarrow PbO_2 + SO_4^{2-} + 4H^+ + 2e^-$$

81) d. 10^{37}

Explanation:

$Zn(s) + Cu^{2+}(aq) \rightleftharpoons Zn^{2+}(aq) + Cu(s)$

The relationship between E°cell and K at 298 K is derived from the Nernst equation at equilibrium ($E_{cell} = 0$).

$$E^\circ_{\text{cell}} = \frac{0.0592\ \text{V}}{n} \log_{10} K$$

$$\log_{10} K = \frac{n \cdot E^\circ_{\text{cell}}}{0.0592\ \text{V}}$$

$$\log_{10} K \approx 37.162$$

$$K = 10^{\log_{10} K}$$

$$K = 10^{37.162}$$

$$K = 10^{0.162} \times 10^{37}$$

$$K \approx 1.45 \times 10^{37}$$

82) a. 4

Explanation:

The total number of atoms in an FCC unit cell is calculated by adding the contributions from the corner and face-centered atoms: (8 corner atoms × 1/8 contribution/atom) + (6 face-centered atoms × 1/2 contribution/atom) = 1 + 3 = 4 atoms.

83) c. NaCl

Explanation:

NaCl: Sodium chloride (NaCl) is a classic example of an ionic solid that exhibits the Schottky defect. The Na^+ and Cl^- ions are of comparable size, and it has a high coordination number (6:6)

84) c. Midway between conduction and valence band

Explanation:

In an intrinsic semiconductor, the Fermi level represents the energy level at which the probability of finding an electron is 50%. Since there are equal numbers of electrons and holes in an intrinsic semiconductor at absolute zero, the Fermi level is situated exactly halfway between the conduction band and valence band.

85) b. 53200

Explanation:

$$M_n = \frac{\sum N_i M_i}{\sum N_i}$$

$$\sum N_i M_i = (200 \times 10^3) + (300 \times 10^4) + (500 \times 10^5)$$

$$\sum N_i M_i = (200 \times 1000) + (300 \times 10000) + (500 \times 100000)$$

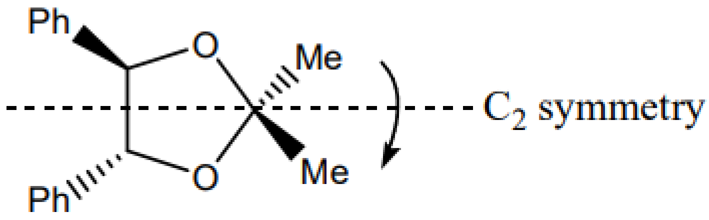
$$\sum N_i M_i = 200000 + 3000000 + 50000000 = 53200000$$

$$\sum N_i = 200 + 300 + 500 = 1000$$

$$M_n = \frac{53200000}{1000} = 53200$$

86) a. homotopic

Explanation:



87) c.

Explanation:

All three methyl groups on same side (above). But in option(a) : 1, 3-diaxial interaction occurs. So, it is less stable conformation. It undergoes ring flipping to give more stable conformation as shown in option (c)

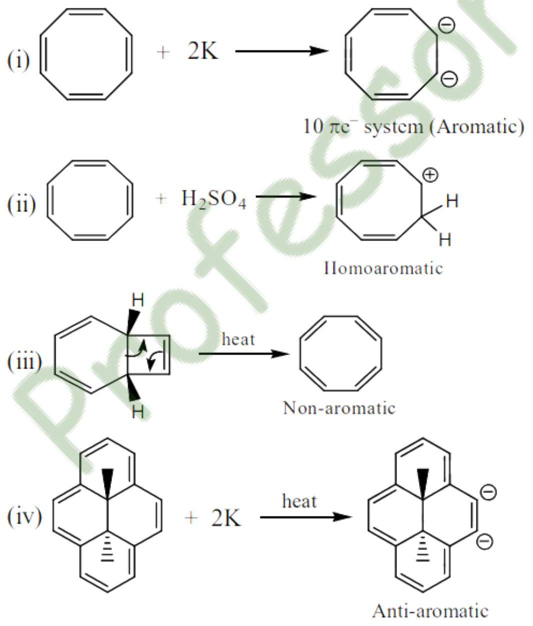
88) b. (i) – (E); (ii) – (B); (iii – (A)

Explanation:

Camphor →Terpene, Insulin → Hormone, Keratin→Structural Protein

89) a. (i)-P, (ii)-S, (iii)-R, (iv)-Q

Explanation:



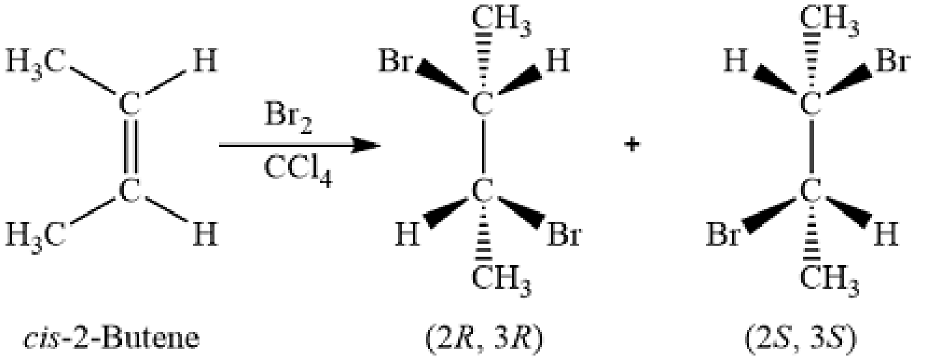
90) d. Carbene

Explanation:

Simmons–Smith reaction: Converts an alkene into a cyclopropane derivative by using the carbenoid species ICH_2ZnI

91) d. Mixture of (2*R*, 3*R*) and (2*S*, 3*S*) dibromobutane

Explanation:



92) b. Observed rotation / (path length × concentration)

Explanation:

The specific rotation [α] is defined as:

$$[\alpha] = \frac{\alpha}{l \times c}$$

α is the Observed Rotation (in degrees), l is the path length (in decimeters, dm) and c is the concentration (in grams per milliliter, $g \cdot mL^{-1}$ or $g \cdot cm^{-3}$)

93) c. Baylis–Hillman reaction

Explanation:

DABCO (1,4-diazabicyclo[2.2.2]octane) is a nucleophilic tertiary amine.

In the Baylis–Hillman reaction, it acts as a nucleophilic catalyst, activating the Michael acceptor (activated alkene) to react with an aldehyde, forming an allylic alcohol.

94) a. 1- C, 2–D, 3–B, 4 – A

Explanation:

Stille coupling (Aryl halide + organotin compound), Heck reaction (Aryl halide + alkene → forms substituted alkenes), Suzuki coupling (Aryl/alkenyl halide organoboron compound) Sonogashira coupling (Aryl halide + terminal alkyne, Pd + Cu(I))

95) b. SN^2 substitution

Explanation:

A stereospecific reaction is one where different stereoisomers of the reactant give different stereoisomers of the product. The SN^2 reaction proceeds with a concerted backside attack of the nucleophile on the carbon bearing the leaving group, resulting in inversion of configuration at the chiral center. SN^1 substitution: This reaction involves the formation of a carbocation intermediate which is planar. The nucleophile can attack from either side of the carbocation, leading to a racemic mixture of products if the starting material is enantiomerically pure. Therefore, SN^1 reactions are not stereospecific. Free radical halogenation involves the formation of free radicals, which are highly reactive and non-stereospecific. Electrophilic aromatic substitution involves the attack of an electrophile on an aromatic ring. While the reaction can be stereoselective in some cases, it is not typically considered stereospecific.

96) b. Carbocation rearrangement

Explanation:

The Wagner–Meerwein rearrangement is a type of 1,2-rearrangement in which a carbocation intermediate is formed and subsequently rearranges to a more stable carbocation.

97) b. α-Diazoketones → ketenes

Explanation:

The Wolff rearrangement involves the conversion of α-diazoketones into ketenes. This reaction is typically initiated by heat (thermolysis), light (photolysis), or a transition metal catalyst, such as silver oxide.

98) d. Anomers

Explanation:

Anomers: Isomers differing in configuration only at the anomeric carbon (C-1 in glucose). α-D-glucose: OH on C-1 is trans to CH_2OH group (on C-5). β-D-glucose: OH on C-1 is cis to CH_2OH group. Epimers: Differ at any carbon other than the anomeric carbon (e.g., D-glucose vs D-mannose at C-2). Enantiomers: Non-superimposable mirror images (D- and L-glucose).

99) b. 328 nm

Explanation:

Base value = 253 nm, Double Bond Conjugation = 30 nm, 5 ring residues – 5*5 = 25 nm, 4 Exocyclic bonds = 4*5= 20 nm, Total λ_{max} = 253 + 30 + 25 + 20 = 328 nm

100) b. Pd/ $CaCO_3$ poisoned

Explanation:

For the stereoselective hydrogenation of an alkyne to a cis-alkene, the required catalyst is Lindlar's catalyst (Pd/$CaCO_3$, poisoned). Pd/C: This is a highly active palladium catalyst that will completely reduce an alkyne to an alkane, not stopping at the alkene stage. (PtO_2), also known as Adams' catalyst, Platinum(IV) oxide (PtO_2) is a potent catalyst used for full hydrogenation. Like (Pd/C), it reduces an alkyne completely to an alkane. Li/NH_3: This reagent, typically lithium or sodium dissolved in liquid ammonia, is used for the stereoselective reduction of an alkyne to a trans-alkene, not a cis-alkene.

101) d. Michael Addition followed by Intramolecular Aldol Condensation

Explanation:

Aldol Condensation followed by Dehydration → That gives α, β-unsaturated carbonyls, not 1,5-dicarbonyl. Ozonolysis followed by Wittig Reaction → Not a standard path to a cyclic 1,5-dicarbonyl. Mannich Reaction followed by Hydrolysis → Produces β-amino carbonyls, not 1,5-dicarbonyl. Michael Addition followed by Intramolecular Aldol Condensation → Yes, this gives a 1,5-dicarbonyl and can close into a six-membered ring. A Michael addition (conjugate addition of an enolate to an α, β-unsaturated carbonyl) directly gives a 1,5-dicarbonyl system. To form a six-membered ring, the 1,5-dicarbonyl intermediate can undergo an intramolecular aldol condensation: one carbonyl forms an enolate and attacks the other carbonyl intramolecularly, closing the ring.

102) a. $4n\pi$, Thermal → Conrotatory

Explanation:

For $4n\pi$-electron systems (e.g., 1,3-butadiene): Thermal conditions: The reaction is conrotatory. Photochemical conditions: The reaction is disrotatory. For $4n+2\pi$ -electron systems (e.g., 1,3,5-hexatriene): Thermal conditions: The reaction is disrotatory. Photochemical conditions: The reaction is conrotatory.

103) c. RNA's sugar has a hydroxyl group (-OH) on the 2' carbon, which is absent in DNA's sugar.

Explanation:

The sugar in DNA is deoxyribose, while the sugar in RNA is ribose. Both are five-carbon sugars, also known as pentoses. The key difference is that deoxyribose lacks an oxygen atom at the 2' position (a hydroxyl group) that is present in ribose.

104) c. 60%

Explanation:

$$ee = \left(\frac{[\alpha]_{sample}}{[\alpha]_{pure}}\right) \times 100\%$$

$$([\alpha]_{pure}) = +50°$$

$$([\alpha]_{sample}) = +30°$$

$$ee = \left(\frac{+30°}{+50°}\right) \times 100\%$$

$$ee = 0.60 \times 100\%$$

$$ee = 60\%$$

105) c. Atropine

Explanation:

Atropine is an alkaloid, not a terpenoid

106) c.

Explanation:

δ 6.50 (broad singlet): This is downfield, likely an NH proton (amide or amine). Broadness is characteristic. δ 2.25 (quartet): This matches a $–CH_2–$ adjacent to electronegative group (like $–CH_2–$ next to C=O in an amide). Quartet → coupled to a CH_3 group. δ 1.10 (triplet): Classic $–CH_3$ coupled to $–CH_2–$.

107) b. Estrogens
Explanation:
Oestrone (also spelled estrone) is a type of estrogen. It is one of the three major naturally occurring estrogens in the human body, along with estradiol and estriol.

108) b. Crystallization
Explanation:
An exothermic peak in a Differential Scanning Calorimetry (DSC) thermogram indicates crystallization. During an exothermic process, the material releases heat, which is detected by the DSC instrument. Melting is an endothermic process, meaning the material absorbs heat. Glass transition temperature (T_g) is a second-order transition where the amorphous part of a material changes from a rigid, glassy state to a more flexible, rubbery state. Sublimation is the process of a substance transitioning directly from a solid to a gas, is an endothermic phase transition.

109) a. Temperature versus mass change of the sample
Explanation:
In TGA (Thermogravimetric Analysis), the mass of the sample is measured as a function of temperature.

110) b. Distance travelled by the solute / distance travelled by the solvent front
Explanation:

$$R_f = \frac{\text{distance traveled by solute}}{\text{distance traveled by solvent front}}$$

111) c. Solvent or solvent mixture
Explanation:
The mobile phase is the liquid that moves through the column, carrying the compounds to be separated, while the stationary phase is the solid material packed in the column (like silica gel or alumina) that interacts with the compounds based on their polarity. Paper is typically used in thin layer chromatography, not column chromatography, and it acts as the stationary phase in that technique.

112) b. Gradient elution
Explanation:
Mobile phase composition changes over time to improve separation. Isocratic elution: Mobile phase composition stays constant. Normal-phase / Reverse-phase: refer to polarity of stationary/mobile phases, not whether composition changes.

113) b. 4
Explanation:
The number 0.007890 has four significant figures: the digits 7, 8, and 9, and the trailing zero after the 9. The three zeros at the beginning of the number are leading zeros and are not significant, while the final zero is a trailing zero that is significant because there is a decimal point.

114) b. Determine if an experimental value is an outlier
Explanation:
The Q-test is used to determine if an experimental value is an outlier.

115) a. Solids
Explanation:
Cone and quartering is a solid sampling technique used to reduce a large bulk sample to a representative laboratory sample.

116) c. Guranteeing analytical results
Explanation:
The sampler ensures representativeness and safety, but cannot guarantee the analysis outcome.

117) c. -1 and 1
Explanation:
The correlation coefficient, denoted by **r**, is a measure of the strength and direction of a linear relationship between two variables. It always has a value between -1 and 1, inclusive [1]. A value of 1 indicates a perfect positive linear relationship, -1 indicates a perfect negative linear relationship, and 0 indicates no linear relationship [1].

118) a. Endothermic peak
Explanation:
Vaporization requires the absorption of heat to convert a liquid into vapor. In DTA (Differential Thermal Analysis), this absorption of heat is recorded as an endothermic peak. Other endothermic events include melting and sublimation. Exothermic peaks correspond to processes that release heat, such as crystallization, solidification, or combustion.

119) b. Difference in wavelength between absorption and emission
Explanation:
When a molecule absorbs light at a specific wavelength (excitation wavelength), it goes into an excited state. When it then emits light, the emitted wavelength is typically longer than the excitation wavelength. This difference in wavelength is called the Stokes shift.

120) b. Colorimetry
Explanation:
Turbidimetry measures the decrease in intensity of transmitted light caused by suspended particles in a solution. This is similar to colorimetry (spectrophotometry), which measures how much light is absorbed by a sample.

121) c. 90°
Explanation:

In nephelometry, the detector is positioned perpendicular (90°) to the incident light beam. This arrangement allows measurement of light scattered by particles while minimizing interference from the transmitted light.

122) b. Liquid solution
Explanation:
In Flame Emission Spectrometry (FES), the sample is usually introduced as a liquid solution. While solid samples can be analyzed with FES, they must first be dissolved in a suitable solvent to be introduced as a liquid solution.

123) b. Hollow cathode lamp
Explanation:
Hollow cathode lamp (HCL) is the most common light source used in Atomic Absorption Spectroscopy (AAS) because it emits radiation at a very specific wavelength corresponding to the element of interest, making it ideal for detecting that element in a sample.

124) a. Fe (II) > Fe (III) > Fe (IV)
Explanation:
The isomer shift (chemical shift) in Mössbauer spectroscopy depends on the s-electron density at the nucleus. Higher electron density → larger isomer shift. In iron compounds: Fe(II) has the highest s-electron density, giving the largest isomer shift. Fe(III) has less s-electron density → intermediate shift. Fe(IV) has the lowest s-electron density, giving the smallest shift.

125) b. A with (ii); B with (i)
Explanation:
(i) High-spin Fe(III) (d^5, $t_{2g}^3 e_g^2$) → symmetric → one peak (ii) High-spin Fe(II) (d^6, $t_{2g}^4 e_g^2$) → strongly asymmetric → clear quadrupole doublet (2 peaks) (iii) low-spin Fe(III) (d^5, t_{2g}^5) – splitting, since its asymmetric.

126) b. Tetramethylsilane
Explanation:
In NMR spectroscopy, the chemical shift (δ) is measured relative to a reference standard. Tetramethylsilane (TMS, $Si(CH_3)_4$) is universally used because single sharp signal → All 12 protons in TMS are equivalent, giving one sharp peak. Chemically inert → Does not react with most organic compounds.

127) b. $\omega_0 = \gamma B_0$
Explanation:
The Larmor equation describes precession of nuclear spins in a magnetic field
$\omega_0 = \gamma B_0$

128) b. Deshielded and shift downfield
Explanation:

In aromatic compounds like benzene, the π-electrons circulate in response to the external magnetic field (B_0). This circulation induces a ring current, which generates a secondary magnetic field. For protons on the aromatic ring, this induced field adds to the external field → resulting in deshielding. Deshielded protons resonate at a higher frequency, appearing downfield ($\delta \sim 7–8$ ppm in benzene).

129) a. Transfer of energy from nuclei to surrounding lattice

Explanation:

Spin-Lattice Relaxation (T_1), also known as Longitudinal Relaxation, is the process by which the nuclear spin system gives the excess energy it absorbed from the RF pulse back to the surrounding molecular environment.

130) a. Chemical Vapor Deposition (CVD)

Explanation:

Bottom-Up synthesis builds nanomaterials from atoms or molecules, assembling them into nanostructures. Chemical Vapor Deposition (CVD) is a classic bottom-up method because it involves chemical reactions of gaseous precursors that deposit atoms/molecules onto a substrate to form nanomaterials. All others are top down method.

131) b. 1-B, 2-C, 3-A, 4-A

Explanation:

Carbon Nanotube: 1D (One-Dimensional), Graphene: 2D (Two-Dimensional), Quantum Dots: 0D (Zero-Dimensional), Fullerene: 0D (Zero-Dimensional).

132) c. Antibiotics

Explanation:

Tetracycline is a broad-spectrum antibiotic that works by inhibiting bacterial protein synthesis. Analgesics → Pain relievers (e.g., aspirin, ibuprofen). Antipyretics → Fever reducers (e.g., paracetamol). Antihistamines → Treat allergies by blocking histamine receptors (e.g., diphenhydramine).

133) a. Pellagra

Explanation:

Pellagra is the disease caused by a severe deficiency of Vitamin B3 (Niacin). It is classically characterized by the "4 D's": Dermatitis (skin lesions), Diarrhoea, Dementia, and ultimately Death if left untreated. Beriberi is caused by a deficiency of Vitamin B1 (Thiamine). Night blindness is an early symptom of Vitamin A deficiency. Scurvy is caused by a deficiency of Vitamin C (Ascorbic acid).

134) a. Crown ether

Explanation:

Crown ethers are cyclic polyethers that contain multiple oxygen atoms in their ring structure. The lone pairs on these oxygen atoms are oriented inward, creating an electron-rich cavity that is specifically designed to bind and coordinate with positively charged ions (cations), such as alkali metal ions (Na^+, K^+, etc.) Cyclodextrins are neutral receptors or hosts for non-polar organic molecules (neutral guests). Porphyrins are large macrocyclic compounds (like heme) often used as metalloreceptors. Fullerenes are neutral/electron acceptor receptors.

135) c. Central Nervous System (CNS) and Renal (Kidney) system

Explanation:

Lead and mercury cross the blood-brain barrier. Causes neurological symptoms: cognitive deficits, memory loss, tremors, peripheral neuropathy. Kidneys are the main excretory organs for heavy metals. Causes tubular damage, proteinuria, and chronic kidney disease. Cardiovascular, respiratory, or musculoskeletal may be affected indirectly, but the most sensitive and primarily damaged systems are CNS and kidneys.

136) a. (Molecular weight of desired product / Total molecular weight of all reactants) × 100

Explanation:

Atom economy (atom efficiency) is a green chemistry metric that measures how efficiently the atoms of the reactants are incorporated into the desired product. It focuses on minimizing waste by ensuring that as many atoms as possible from the starting materials end up in the final product. Atom economy = (Molecular weight of desired product / Total molecular weight of all reactants) × 100

137) a. SEM

Explanation:

Energy Dispersive X-ray Spectroscopy (EDS) is an analytical technique used to determine the elemental composition of a sample. It works by detecting characteristic X-rays emitted from the sample when it is bombarded with an electron beam. SEM (Scanning Electron Microscope) provides a focused electron beam that interacts with the sample surface, producing secondary electrons (for imaging) and X-rays (for EDS analysis). EDS is commonly coupled with SEM to get both high-resolution surface images and elemental composition simultaneously. AFM (Atomic Force Microscopy): Measures surface topography using a probe tip; does not generate X-rays. XPS (X-ray Photoelectron Spectroscopy): Uses X-rays to eject electrons, not for EDS. STM (Scanning Tunnelling Microscopy): Measures tunnelling current; no X-ray detection is involved.

138) b. The relaxation of an excited atom after core-level ionization.

Explanation:

The process begins when an inner shell electron is ejected, creating a core hole; the subsequent relaxation of an electron from a higher shell fills this hole, and the energy released is transferred to a third electron, the Auger electron.

139) a. 31°C and 73.8 atm

Explanation:

Critical temperature (T_c) is the highest temperature at which a substance can exist as a liquid. For CO_2, the critical temperature is 30.98°C, which is very close to 31°C. Critical pressure (P_c) is the vapor pressure at the critical temperature. For CO_2, the critical pressure is 72.8 atm, which is very close to 73.8 atm.

140) c. They are also known as cage compounds due to their structure.

Explanation:

Clathrates are inclusion compounds in which a host lattice forms a cage-like structure that traps guest molecules. The guest molecules are not chemically bonded to the host; they are held by weak interactions like van der Waals forces, hydrogen bonding, or electrostatic interactions. They can form with a variety of hosts and guests, not just water or noble gases. Clathrates are widely used for gas storage and transportation, such as methane hydrates.