Q1.
Which of the following diatomic species is paramagnetic?

A) O_2
B) N_2
C) F_2
D) CO
E) NO^+

Q2.
Which of the following statements about the CO_3^{2-} ion is false?

A) One C–O bond is shorter than the other.
B) The orbitals on the carbon atom are sp^2 hybridized.
C) The ion has three resonance structures.
D) The ion has a total of 24 valence electrons.
E) The ion has 3 sigma bonds.

Q3.
The hybridization of the central atom in XeF_5^+ and ClF_3 are,

A) d^2sp^3 and dsp^3 respectively.
B) dsp^3 and sp^2 respectively.
C) dsp^3 and sp^3 respectively.
D) d^2sp^3 and sp^3 respectively.
E) d^2p^3 and d^2sp^3respectively.

Q4.
Which of the following has the highest bond order?

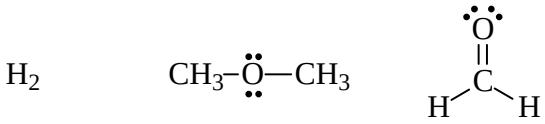
A) O_2^{2+}
B) O_2^+
C) O_2
D) O_2^-
E) O_2^{2-}

Q5.
Which of the following electron configurations is correct for CO by the molecular orbital model?

A) $(\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2p})^4 (\sigma_{2p})^2$
B) $(\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2p})^4 (\sigma_{2p})^1$
C) $(\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2p})^4$
D) $(\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\sigma_{2p})^2 (\pi_{2p})^4 (\pi_{2p}^*)^2$

E) $(\sigma_{2s})^2\ (\sigma_{2s}^*)^2\ (\sigma_{2p})^2\ (\pi_{2p})^4\ (\pi_{2p}^*)^4(\sigma_{2p}^*)^2$

Q6.
Which of the following would show hydrogen bonding?



H_2	$CH_3{-}\ddot{O}{-}CH_3$		H_2O_2	N_2H_4
hydrogen	dimethyl ether	formaldehyde	hydrogen peroxide	hydrazine
(i)	(ii)	(iii)	(iv)	(v)

A) (iv) and (v) only
B) (i), (iv) and (v) only
C) (iii), (iv) and (v) only
D) all compounds except (i)
E) all compounds except (ii)

Q7.
Of the following, the substance with the highest melting point is

A) calcium fluoride
B) fluorine
C) dioxygen difluoride
D) silicon tetrafluoride
E) phosphorous pentafluoride

Q8.
The element iron crystallizes in a form called α-iron, which has a body-centered cubic unit cell. The body-centered cubic unit cell of α-iron is 0.28864 nm on each side. Calculate the density of this form of iron.

A) 7.713 g/cm^3
B) 15.43 g/cm^3
C) 3.857 g/cm^3
D) 1.841g/cm^3
E) 3.683 g/cm^3

Q9.
Ethanol (C_2H_5OH) melts at –114.0^{o}C and boils at 78.0^{o}C. How much heat is required to convert 75.0 g of ethanol at –120.0^{o}C to the vapor phase at 78.0^{o}C?

Enthalpy of fusion ΔH_{fus} of ethanol = 5.02 kJ/mol
Enthalpy of vaporization ΔH_{vap} of ethanol = 38.56 kJ/mol
Specific heat of solid ethanol = 0.970 J/g.^{o}C

Specific heat of liquid ethanol = 2.300 J/g.^{o}C

A) 105 kJ
B) 3.30 x 10^3 kJ
C) 88.8 kJ
D) 91.5 kJ
E) 71.7 kJ

Q10.
Octane, C_8H_{18}, is the principal component of gasoline. It has a vapor pressure of 145 mm Hg at 75.0^{o}C and 20.0 mm Hg at 32.0^{o}C. Calculate its vapor pressure at 85.0^{o}C.

A) 215 mm Hg.
B) 173 mm Hg
C) 142 mm Hg
D) 128 mm Hg
E) 56.8 mm Hg

Q11.
Which of the following substances can be liquefied by applying pressure at 25^{o}C?

	SUBSTANCE	**CRITICAL TEMPERATURE**	**CRITICAL PRESSURE**
(i)	Sulfur dioxide	158^{o}C	78 atm
(ii)	Acetylene	36^{o}C	62 atm
(iii)	Methane	–82^{o}C	46 atm
(iv)	Carbon monoxide	–140^{o}C	35 atm

A) (i) and (ii) only.
B) (iii) and (iv) only.
C) All substances.
D) The given information is not enough to answer this question.
E) (i) and (iv) because of being polar compounds.

Q12.
Cobalt fluoride crystallizes in a cubic closed packed array in which fluoride ions forms face-centered cubic structure with the cobalt ions filling one-half of the octahedral holes. What is the formula of this compound?

A) CoF_2
B) CoF_3
C) Co_2F_5
D) Co_3F_4
E) CoF

Q13.
Give the result of the following mathematical operations to the correct number of significant figures.

$$\frac{3.21\ (\ 26 + 3.431\ )}{4.731}$$

A) 20.
B) 19.9
C) 19.96
D) 18.3
E) 35

Sec# Chemical Foundations - Uncertainty in Measurement
Grade# 65

Q14.
It is estimated that uranium is relatively common in the earth's crust, occurring in amounts of 4 g/metric ton. A metric ton is 1000 kg. At this concentration, what mass of uranium is present in 1.0 mg of the earth's crust?

A) 4 nanograms
B) 4 micrograms
C) 4 milligrams
D) 4×10^{-5}g
E) 4 centigrams

Q15.

With what volume of 5.0 M HF will 7.4 g of calcium hydroxide react completely, according to the following reaction?

$$2HF + Ca(OH)_2 \rightarrow CaF_2 + 2H_2O$$

A) 40. mL
B) 50. mL
C) 30. mL
D) 20. mL
E) 1.0×10^2 mL

Q16.
Balance the following oxidation–reduction reaction using the half-reaction method.

$Cr_2O_7^{2-} + I_2 \rightarrow Cr^{3+} + IO_3^-$ (acidic solution)

In the balanced equation, the coefficient of water is,

A) 17
B) 4
C) 11
D) 7
E) 6

Q17.
A 1.000-g sample of a metal chloride, MCl_2, is dissolved in water and treated with excess aqueous silver nitrate. The silver chloride that formed weighed 1.286 g. Calculate the atomic mass of M.

A) 152.0 g/mol
B) 76.00 g/mol
C) 222.8 g/mol
D) 304.0 g/mol
E) 453.0 g/mol

Q18.
In a certain condition, nitrogen reacts with oxygen to form two compounds. The mass of oxygen that combines with 1.00 g of nitrogen for each compound is 2.286 g and 3.429 g respectively. The ratio of the masses of nitrogen in these two compounds would be,

A) 2/3
B) 1/2
C) 1/3
D) 2/1
E) 3/1

Q19.
Name the compound $CoPO_4$.

A) Cobalt(III) phosphate
B) Cobalt(II) phosphate
C) Cobalt (II) phosphide
D) Cobalt phosphate
E) Cobalt(III) phosphide

Sec# Atoms, Molecules, and Ions - Naming Simple Compounds
Grade# 65

Q20.
An inflated balloon has a volume of 7.5 L at sea level (1.0 atm) and is allowed to rise to a point in the atmosphere where the pressure is 0.45 atm. During rise the

temperature of the gas falls from 22°C to –21°C. Calculate the volume of the balloon at its final height.

A) 14 L
B) 20. L
C) 16 L
D) 2.9 L
E) 6.4 L

Q21.
The safety airbags in automobiles are inflated (blown) by nitrogen gas generated by the rapid decomposition of sodium azide, NaN_3,

$2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$

If an air bag has a volume of 37.0 L and is to be filled with nitrogen gas at a pressure of 1.15 atm at a temperature of 25.0°C, how many grams of NaN_3 must be decomposed?

A) 75.4 g
B) 1.70×10^2 g
C) 113 g
D) 146 g
E) 37.7 g

Q22.
In an effusion experiment, 12.0 seconds are required for 1.00 L of O_2 to effuse through a pinhole. How long will it take for the same volume of NO_2 to effuse under identical conditions?

A) 14.4 sec
B) 17.3 sec
C) 15.6 sec
D) 12.0 sec
E) 10.0 sec

Sec# Gases - Effusion and Diffusion
Grade# 75

Q23.
.Consider the following reaction;

$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s) \qquad \Delta H = -1652$ kJ

How much heat is released when 10.0 g Fe is reacted with excess O_2?

A) -73.9 kJ
B) -34.4 kJ

C) -65.8 kJ
D) +85.6 kJ
E) –125 kJ

Q24.
A 30.0 g sample of water at 280. K is mixed with 50.0 g of water at 330. K. What is the final temperature of the mixture assuming no heat loss to the surroundings? Specific of heat of water = 4.18 J/g °C

A) 311K
B) 150.K
C) 75 K
D) 235 K
E) 305 K

Q25.
The de Broglie wavelength of an electron (mass = 9.11×10^{-31} kg) with a velocity 10.% of the speed of light would be,

A) 2.4×10^{-11} m
B) 1.32×10^{-13} m
C) 4.4×10^{-34} m
D) 3.6×10^{-10} m
E) 3.52×10^{-7} m

Q26.
The successive ionization energies for an unknown element are I_1 = 896 kJ/mol, I_2 = 1752 kJ/mol, I_3 = 14807 kJ/mol, I_4 = 17948 kJ/mol. To which family in the periodic table does the unknown element most likely belong?

A) Alkaline earth metals
B) Alkali metals
C) Transition metals
D) Halogens
E) Noble gases

Q27.
In the ground state of cadmium, Cd, how many electrons have m_l = -1 as one of their quantum numbers?

A) 10
B) 18
C) 24
D) 48
E) 5

Q28.
Given the bond energies (in kJ/mol) for H—H, Br—Br, and H—Br as 436, 193, and 368 respectively, calculate the heat of formation of H—Br from gaseous H_2 and Br_2.

A) -54 kJ/mol
B) -65 kJ/ mol
C) -107 kJ/mol
D) -131 kJ/mol
E) -150 kJ/mol

Q29.
Which one of the following compounds does not obey the octet rule?

A) PF_5
B) NF_3
C) AsH_3
D) CF_4
E) CO_2

Q30.
Arrange the following ions in order of decreasing size.

I^-, Cs^+, La^{3+}, Ba^{2+}, Te^{2-}

A) $Te^{2-} > I^- > Cs^+ > Ba^{2+} > La^{3+}$
B) $Te^{2-} > Ba^{2+} > Cs^+ > I^- > La^{3+}$
C) $Te^{2-} > Cs^+ > Ba^{2+} > I^- > La^{3+}$
D) $La^{3+} > Ba^{2+} > Cs^+ > I^- > Te^{2-}$
E) $I^- > Cs^+ > Te^{2-} > La^{3+} > Ba^{2+}$

Q31.
A compound contains only carbon, hydrogen, and oxygen. Combustion of 10.86 mg of the compound yields 16.01 mg CO_2 and 4.37 mg H_2O. The molar mass of the compound is 176.1 g/mol. What is the molecular formula of the compound?

A) $C_6H_8O_6$
B) $C_6H_{12}O_6$
C) $C_2H_5O_4$
D) $C_3H_8O_3$
E) $C_3H_{12}O_9$

Q32.
Natural rubidium has the average mass of 85.4678 amu and is composed of isotopes ^{85}Rb (mass = 84.9117 amu) and ^{87}Rb. The ratio of atoms $^{85}Rb/^{87}Rb$ in natural rubidium is 2.591. Calculate the mass of ^{87}Rb.

A) 86.9087 amu
B) 86.0012 amu
C) 88.9125 amu
D) 85.9035 amu
E) 87.9526 amu

Sec# Stoichiometry - Atomic Masses
Grade# 65

Q33.
Considering the following unbalanced reaction:

$B_5H_9(l) + O_2(g) \rightarrow B_2O_3(s) + H_2O(g)$

If 126 g of B_5H_9 is mixed with 192 g of O_2, what mass of water will be produced?

A) 81.1 g
B) 144 g
C) 50.5 g
D) 15.2 g
E) 35.8 g

Sec# Stoichiometry - Stoichiometric Calculations: Amounts of Reactant and Products
Grade# 65

Q34.
The freezing point of a solution of NaCl in 1.00 kg of water was found to be -0.426^oC. Assuming ideal behavior, calculate the mass of NaCl in solution.
Molal freeze-point depression constant K_f of water = 1.86 °C.kg/mol

A) 6.69 g
B) 13.3 g
C) 25.2 g
D) 8.75 g
E) 38.2 g

Sec# Properties of Solutions - Boiling-Point Elevation and Freezing-Point Depression
Grade# 65

Q35.
A bottle contains 12.5% ethanol (C_2H_5OH) by volume. The density of ethanol is 0.789 g/cm^3. Calculate the molality of ethanol. (Density of water = 1.00 g/cm^3)

A) 2.45 m
B) 5.24 m
C) 1.52 m
D) 12.3 m

E) 8.24 m

Q36.
The vapor pressure of a solution containing 53.6 g glycerin ($C_3H_8O_3$) in 133.7 g ethanol (C_2H_5OH) is 11.3 torr at 40°C. Calculate the vapor pressure of pure ethanol at 40°C assuming that glycerin is nonvolatile, nonelectrolyte solute in ethanol.

A) 13.6 torr
B) 9.41 torr
C) 36.6 torr
D) 25.3 torr
E) 42.3 torr

Q37.
A sample weighing 1.00×10^{-3} g was dissolved in water to make 1.00 mL solution. The osmotic pressure of the solution was found to be 1.12 torr at 25.0°C. Calculate the molar mass of the sample.

A) 1.66×10^{4} g/mol
B) 2.45×10^{4} g/mol
C) 3.45×10^{5} g/mol
D) 6.23×10^{3} g/mol
E) 4.57×10^{6} g/mol

Q38.
The solubility of nitrogen in water is 8.21×10^{-4} mol/L at 0°C when the N_2 pressure above water is 0.790 atm. Calculate the solubility of N_2 in water when the partial pressure of nitrogen above water is 1.10 atm at 0°C.

A) 1.14×10^{-3} mol/L
B) 2.04×10^{-3} mol/L
C) 8.26×10^{-2} mol/L
D) 1.56×10^{-4} mol/L
E) 5.26×10^{-1} mol/L

Q39.
Which of the following aqueous solutions has the lowest freezing point?

A) 0.15 m Na_2SO_4
B) 0.18 m KCl
C) 0.12 m $Ca(NO_3)_2$
D) pure water
E) 0.20 m $C_2H_6O_2$ (ethylene glycol)

Q40.

Glycerine, $C_3H_8O_3$, is a nonvolatile liquid. What is the vapor pressure of the solution made by adding 164 g of glycerine to 338 mL of water(H_2O) at 39.8°C?
Vapor pressure of pure water at 39.8°C = 54.74 torr
Density of water at 39.8°C = 0.992 g/cm^3

A) 50.0 torr
B) 65.2 torr
C) 43.7 torr
D) 123 torr
E) 25.0 torr
