Brainiacs Chemistry Olympiad Preliminary Round Sample Exam Paper 2

Category III – grades 11 and 12

Q1.
Which subatomic particle determines the chemical behavior of an element?
A) Proton
B) Neutron
C) Electron
D) Nucleus

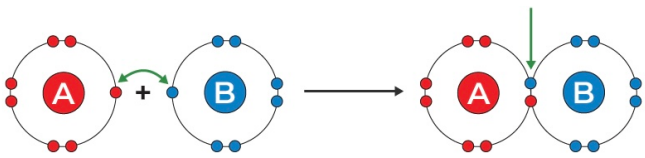
Q2.
What is the formula for calculating the molarity of a solution?
A) Molarity = moles of solute / liters of solution
B) Molarity = mass of solute / volume of solvent
C) Molarity = volume of solute / moles of solution
D) Molarity = moles of solute / grams of solution

Q3. Which of the following molecules exhibits hydrogen bonding?
A) CH_4
B) H_2S
C) H_2O
D) CO_2

Q4.
Which gas law states that the volume of a gas increases directly in proportion to its temperature, provided the pressure remains constant?
A) Boyle's Law
B) Charles's Law
C) Avogadro's Law
D) Dalton's Law

Q5. How many unpaired electrons are in the ground state electron configuration of Cr^{3+}?
A) 0
B) 1
C) 3
D) 5

Q6.
Chemical bonds are the foundation of chemistry and biology, enabling the creation of diverse materials and biological systems. Their importance lies in shaping properties, influencing chemical reactions, and determining biological function.



What type of bond involves the sharing of electron pairs between atoms?
A) Ionic
B) Covalent
C) Metallic
D) Hydrogen

Q7.
Compound A importance lies in its versatility, effectiveness, and widespread applications across industries, including healthcare, food and beverage, environmental remediation, and manufacturing. Its unique properties make it an essential component in various processes, from disinfection and sterilization to biological signaling and rocket propulsion.
What is the common name for compound A?
A) Water
B) Hydrogen peroxide
C) Methane
D) Ammonia

Q8.
When acids and bases are mixed together, a chemical reaction occurs. This reaction is called a neutralization reaction. For example, toothpaste contains bases that neutralize the acid produced by bacteria in our mouth.

acid + base → ..... + water

What is the missing part of this neutralization equation?
A) Carbon dioxide
B) Hydrogen
C) Oxygen
D) Salt

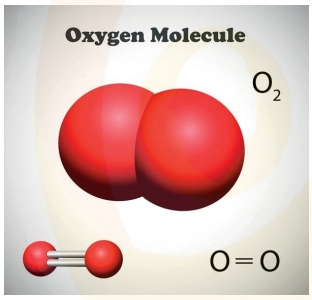
Q9.
What is the pOH of a solution with a hydrogen ion concentration of 10^{-4} M?
A) 2
B) 4
C) 6

D) 10

Q10.
A hydrocarbon has the following elemental composition (by mass): 82.76% carbon and 17.24% hydrogen. Upon chlorination (radical), the hydrocarbon forms two isomeric monochlorides — primary and tertiary. Determine the structure of the original hydrocarbon.

A) 2-methyl propane
B) Butane
C) 2-methyl pentane
D) 2-methyl butane

Q11.
Oxygen is essential for maintaining optimal health and well-being. Ensuring adequate oxygen supply through proper breathing techniques, exercise, and environmental factors can have a significant impact on overall health and quality of life.



In which of the following processes is oxygen reduced?
A) Combustion of CH_4
B) Formation of water
C) Decomposition of H_2O_2
D) Reaction of Fe with O_2 to form rust

Q12.
A gaseous hydrocarbon contains 85.7% carbon by mass. Its density is 1.875 g/L at STP. Determine the` molecular formula of the compound:
A) C_2H_2
B) C_2H_4
C) C_3H_6
D) C_4H_{10}

Q13.
In the reaction $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$, doubling the concentration of NO increases the reaction rate by four times. What is the order of the reaction with respect to NO?
A) Zero
B) First

C) Second
D) Third

Q14.
Natural fibers are fibers that are produced by geological processes, or from the bodies of plants or animals. They can be used as a component of composite materials, where the orientation of fibers impacts the properties. Natural fibers can also be matted into sheets to make paper or felt.
Which of the following is the strongest natural fiber?

A) Cotton
B) Jute
C) Silk
D) More than one of the above

Q15.
A voltaic cell is constructed with Cd and Mn electrode. Given the following half-reactions and their standard reduction potential, E°.
What is the direction of electron flow in the external circuit if the concentration of each solution is 1M?

$Cd^{2+}(aq) + 2e^- \longrightarrow Cd(s)$ $\quad E° = -0.403\ V$

$Mn^{2+}(aq) + 2e^- \longrightarrow Mn(s)$ $\quad E° = -1.180\ V$

A) From Mn anode to Cd cathode
B) From Cd cathode to Mn anode
C) From Mn cathode to Cd anode
D) From Cd anode to Cd cathode

Q16.
Calculate the Gibbs free energy change (ΔG) at 298 K for a reaction with ΔH = -100 kJ and ΔS = -200 J/K.
A) -40 kJ
B) -60 kJ
C) -80 kJ
D) -100 kJ

Q17.

The pKa of acetic acid is 4.76. What is the pH of a solution prepared by mixing 50 mL of 0.1 M acetic acid and 50 mL of 0.1 M sodium acetate?
A) 3.76
B) 4.76
C) 5.76
D) 6.76

Q18.
Determine the molar concentration of nitric acid HNO_3 obtained by mixing 40 mL of a 96% solution of HNO_3 (density 1.5 g/mL) with 30 mL of a 48% solution of HNO_3 (density 1.3 g/mL). The density of the resulting solution is 1.45 g/mL.
A) 17,7M
B) 15,6M
C) 10,4M
D) 5,6M

Q19.
A mixture of calcium, calcium oxide, and calcium carbide is given, with a molar ratio of the components 1:3:4 (in the order listed). What volume of water can react chemically with 35 g of this mixture?
A) 20,5ml
B) 17,6ml
C) 32,3ml
D) 12,8ml

Q20.
48 g of a mineral containing 46.7% iron and 53.3% sulfur by weight were burned in excess oxygen, and the solid combustion product was calcined with 18.1 g of aluminum. What amount of heat was released as a result of each of these reactions (the reactions were carried out at a constant temperature)? The heats of formation at this temperature are: iron sulfide 174 kJ/mol, iron(III) oxide 824 kJ/mol, sulfur(IV) oxide 297 kJ/mol, aluminum oxide 1675 kJ/mol.
A) 432.4 kJ and 523.2 kJ
B) 356.8 kJ and 498.6 kJ
C) 332.8 kJ and 170.2 kJ
D) 234.6 kJ and 134.8 kJ