River Valley High School

2024 JC 2 H1 Chemistry 8873 Prelim Exam Paper 1 Worked Solutions

1	A	The decomposition involves: $n \rightarrow p^+ + e^-$ where the newly-formed proton stays in the nucleus. As the proton number of the atom increases by 1 following the decomposition, the element will no longer be the same. Options B and D are eliminated. Option A involves an increase in proton number by 1 going from K to Ca, hence it is the correct answer.
2	C	Option A: By definition, one mole of a substance contains exactly 6.02×10^{23} (or Avogadro number) elementary entities. Option A is incorrect because of the phrase "same number of atoms as there are in 12.000 g of carbon-12". Option B: By definition, relative isotopic mass (A_r) is the mass of one mole of atoms of an isotope (of a certain element) relative to $\frac{1}{12}$ the mass of one mole of ^{12}C atoms. Option B is incorrect because in the formula given, the numerator used is "average mass of all isotopes of lithium". Option C: By definition, relative atomic mass (A_r) is the average mass of one mole of atoms of an element relative to $\frac{1}{12}$ the mass of one mole of ^{12}C atoms. Note that some textbooks define relative atomic mass as "the average mass of one atom of an element relative to $\frac{1}{12}$ the mass of one ^{12}C atom". Hence, option C is correct. Option D: By definition, relative molecular (M_r) mass is the average mass of one mole of molecules relative to $\frac{1}{12}$ the mass of one mole of ^{12}C atoms. Option D is incorrect because in the formula given, the numerator used is "average mass of one atom of E".

3	A	Statement 1: Correct According to Aufbau's build up principle, in the ground state of an atom or ion, electrons fill atomic orbitals of the lowest available energy level before occupying higher-energy levels. Statement 2: Incorrect The order of filling the orbitals is 1s, 2s, 2p, 3s, 3p, 4s, 3d. Statement 3: Incorrect The shell with principal quantum number 2 only has 2s and 2p orbitals. Hence, it can hold a maximum of 8 electrons.
4	D	A: Due to the overlap of unhybridised 2p orbitals, mobile delocalised electrons are found in the lattice structure. B: Each carbon atom forms 3 sigma bonds with 3 other carbon atoms. C: Instantaneous dipole-induced dipole interactions exist between each graphite plane. D: Conduction of electricity occurs due to the overlap of unhybridised 2p orbitals. The overlapping occurs <u>perpendicular</u> to the axis of the unhybridised 2p orbitals.
5	A	A: There is an unpaired electron on N atom in NO_2 molecule. B: The Cu^+ ion has an electronic configuration of $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^0$. C: The Li^+ ion has an electronic configuration of $1s^2\ 2s^0$. D: After heterolytic fission, Cl^+ and $Cl^\#$ ions are formed, which do not have a single unpaired electron.
6	B	When indicator P turns yellow, it means pH of solution is higher than 5. When indicator Q turns yellow, it means pH of solution is less than 5.7. Therefore, pH range of the solution is between 5 to 5.7.

7	A	A: Recall that H^+ does not contain any electrons so the total number of electrons in both $CO_3^{2\#}$ and $HCO_3^{\#}$ are the same (32 electrons). B: The blood buffer system consists of H_2CO_3 and $HCO_3^{\#}$. C: While $CO_3^{2\#}$ can only exhibit basic property (as the conjugate base of $HCO_3^{\#}$), $HCO_3^{\#}$can both exhibit acidic (as the conjugate acid of $CO_3^{2\#}$) and basic property (as the conjugate base of H_2CO_3). D: They are a conjugate acid-base pair as they differ by 1 proton (H^+). A random combination of a weak acid and a weak base does not constitute a conjugate acid-base pair.
8	D	The volume for equivalence point is 10 cm^3. Thus, the molar ratio of acid and base used is 1: 1 which implies that the acid is monobasic. Therefore options A and B are not possible. Since the equivalence point is above 7, this will mean that the titration is between a strong base and a weak monobasic acid. Therefore the answer is D.
9	B	Option A is correct: Anionic size decreases in the order of $P^{3-} > S^{2-} > Cl^-$. Option B is incorrect: The element with the highest melting point is silicon, which has giant covalent structure. Option C is correct: Aluminium has giant metallic lattice structure. Due to the highest number of delocalised valence electrons (per atom), aluminium has the highest electrical conductivity. Option D is correct: Sulfur exists as S_8 molecules.
10	A	Step I: MgO is basic in nature and does not react with NaOH. $Al_2O_3(s) + 2NaOH(aq) + 3H_2O(l) \rightarrow 2Na[Al(OH)_4](aq)$ SiO_2 only reacts with concentrated alkali. Step II: Filtrate contains $Na[Al(OH)_4]$. Residue contains MgO and SiO_2. Step III: $MgO(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2O(l)$ SiO_2 is acidic in nature and does not react with HCl. Step IV: Filtrate contains $Mg^{2+}(aq)$. Residue contains SiO_2.

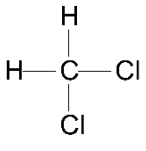
11	D	Option A: Correct for both Group 1 and Group 17. Down both Group 1 and Group 17, the valence electron to be removed is further away from the nucleus. Hence, the ionisation energies decrease down the groups. Option B: Correct for both Group 1and Group 17. Group 1 elements act as reducing agents and get oxidised themselves. Oxidation involves the loss of electrons. Down Group 1, it is easier to lose the valence electron as it is further from the nucleus. Hence, reducing power increases down Group 1. Group 17 elements act as oxidising agents and get reduced themselves. Reduction involves the gain of electrons. Down Group 17, it is harder to gain electrons because the electrons gained are placed further away from the nucleus and experience weaker nuclear attraction. Hence, the oxidising power of Group 17 elements decreases down the group. Option C: Correct for both Group 1 and Group 17. In general, Group 1 elements are good reducing agents while Group 17 elements are good oxidising agents. Option D: Incorrect because across the period, atomic radius decreases. Thus a Group 1 element should have larger atomic radius than a Group 17 element in the same Period.

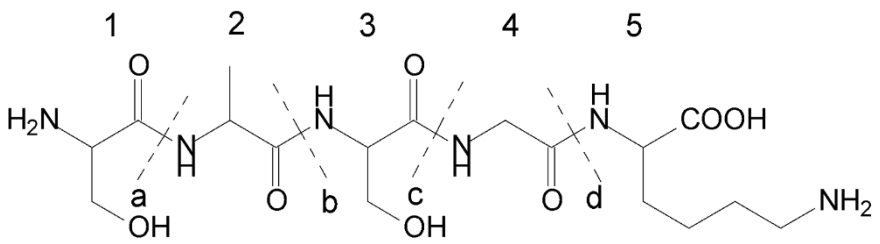
12	C	Amount of CO_2 = $\frac{48.0}{24\,000}$ = 0.00200 mol Amount of sodium percarbonate = $0.100 \times \frac{10.0}{1000}$ = 0.00100 mol $(Na_2CO_3)_x \bullet_y (H_2O_2)$: CO_2 x : 1 0.00200 : 0.00100 2 : 1 Therefore, x = 2 Amount of H_2O_2 = 0.00100y mol Amount of $KMnO_4$ = $0.0500 \times \frac{24.0}{1000}$ = 0.00120 mol Given the ratio is 2 : 5 $\frac{0.00120}{0.00100y} = \frac{2}{5}$ y = 3 Therefore, $\frac{y}{x} = \frac{3}{2}$
13	B	Amount of ethanol produced = (100 × 1000)/46.0 = 2173 mol Amount of carbon dioxide required = 2 × 2173 = 4347 mol Volume of carbon dioxide required = 4347 × 22.7 = 98676.9 = 98700 dm^3

14	C	Option A: Incorrect Amount of potassium chloride = 74.6 / 74.6 = 1 mol Amount of ions = 1 × 2 = 2 mol No. of ions = 2 × 6.02 × 10^{23} = 1.20 × 10^{24} Option B: Incorrect Amount of CO_2 = 44/44 = 1 mol Amount of atoms = 1 × 3 = 3 mol No. of atoms = 3 × 6.02 × 10^{23} = 1.81 × 10^{24} Option C: Correct Amount of nitric acid, HNO_3 = 0.5 mol Amount of ions = 0.5 × 2 = 1 mol No. of ions = 1 × 6.02 × 10^{23} = 6.02 × 10^{23} Option D: Incorrect Amount of delocalised electrons = 3 mol No. of delocalised electrons = 3 × 6.02 × 10^{23} = 1.81 × 10^{24}
15	B	$H_2S(g) + ½O_2(g) \rightarrow H_2O(g) + S(s)$ ΔH_r = –243.0 – (–20.5) = –222.5 kJ mol^{-1}

16	A	Option A: Correct. Bond dissociation energy: $HF(g) \rightarrow H(g) + F(g)$ $+565\ kJ\ mol^{-1}$ The reverse of the above reaction results in 565 kJ of energy released. Option B: Incorrect because change of state from liquid to gas is endothermic. Heat is absorbed and not released. Option C: Incorrect because the equation is showing the endothermic process of bond dissociation of H#F. The equation is shown under option A. Option D: Incorrect. The equation is showing the enthalpy of formation of HF. Using the bond energies found in Data Booklet, $\Delta H = (0.5)(+436) + (0.5)(+158) - (+562) = -265\ kJ\ mol^{-1}$
17	B	Statement 1: Correct Introducing a catalyst will lower the E_a and hence increase the rate constant for both the forward and backward reactions. Statement 2: Correct Increasing temperature will increase the average kinetic energy of both the reactants and products and the frequency of effective collisions. Hence, the rate constant of both the forward and backward reactions will increase. Statement 3: Incorrect Increase in concentration of reactants might increase rate but does not affect rate constant.
18	C	Since total volume of the reaction mixture is kept constant, the concentration of Y and Z in the reaction mixture is directly proportional to the volume of each reagent used. Comparing Expt 1 and 3, reaction is second order with respect to [Z]. Comparing Expt 2 and 3, reaction is first order with respect to [Y].

19	C	Pressure: There are three moles of gaseous reactants and only one mole of gaseous product. An increase in pressure will cause the POE to shift right and favour the forward reactant to reduce the amount of gaseous particles present in order to reduce pressure. Hence, an increase in pressure will increase the amount of methanol. Temperature: Given that ΔH = negative, the forward reaction is exothermic. A decrease in temperature will cause the POE to shift right to favour the forward exothermic reaction to increase temperature. Hence, a decrease in temperature will increase the amount of methanol.
20	D	$[OH^{\#}] = K_w/[H^+] = 2.42 \times 10^{\#14} \div 10^{\#7.40} = 6.08 \times 10^{\#7}$ mol $dm^{\#3}$
21	C	Option 2 is not true as there are weak instantaneous dipole-induced dipole interactions between the wall and the nano-structures of gecko's feet.
22	C	Nanoparticles are materials with all 3 dimensions measuring between 1 to 100 nm.
23	D	Soft contact lenses: Poly(vinyl alcohol) forms hydrogen bonding with moisture in the eyes so that the eyes will not dry out. Wrinkle resistant shirts: Polyester does not form hydrogen bonds with itself compared to polyamides. Hence, it is less prone to creasing.
24	B	Option 1: With the presence of alcohol groups, PVA is expected to be soluble in water and is commonly used as eye drops. Option 2: PET is a suitable material to make soft drink bottles where soft drink is acidic. It is, however, prone to alkaline hydrolysis. Option 3: Nylon is commonly used as fabric. It can cease easily due to the presence of amide linkages that can form hydrogen bonding. Option 4: PVC is an addition polymer that is chemically inert. It is also a suitable material to make bottles.

25	A	Statement 1: Correct as the polymer is an addition polymer with its monomer containing an alkene functional group. Statement 2: Incorrect as the main functional group in the polymer is a halogenoalkane, which cannot undergo hydrolysis to be broken back to its monomer. This polymer does not contain an ester or amide group for hydrolysis to occur. Statement 3: Incorrect as the alkene is 2-chloro-3-methylbut-2-ene rather than 2-chlorobut-2-ene.
26	B	Option A is incorrect. $LiAlH_4$ in dry ether does not reduce alkene. Option B is correct. Bromoethane undergoes elimination to give alkene using ethanolic NaOH, heat under reflux. Option C is incorrect. To obtain aldehyde from primary alcohol requires acidified $K_2Cr_2O_7$, heat with immediate distillation. Option D is incorrect. To obtain primary amine from bromoethane requires heating with excess ethanolic NH_3 in a sealed tube.
27	C	Methane, an alkane, undergoes free radical substitution reaction with excess chlorine in the presence of UV light to form poly-chlorinated product.  , ^{35}Cl and ^{35}Cl, M_r = 84

28	C	 Hydrolysis of amide bond (b) only leads to fragment 1-2 (i.e. option A). Hydrolysis of amide bond (b) and (d) leads to fragment 3-4 (i.e. option B). Hydrolysis of amide bond (d) only leads to fragment 5 (i.e. option D). As 2 and 4 are not bonded directly, option C cannot be formed from the partial hydrolysis.
29	D	Option A is wrong. Although carvone's alkene and ketone group will be reduced by $H_2(g)$ with nickel catalyst and heat, this reaction does not give any observable change. Option B is wrong. Carvone contains alkene and ketone functional groups, none of which will undergo elimination with excess hot concentrated H_2SO_4. Option C is wrong. Carvone contains alkene and ketone functional groups, none of which will be oxidised by $K_2Cr_2O_7$. Option D is correct. Carvone's alkene group undergoes addition with Br_2. Orange-red Br_2 will decolourise.
30	B	Statement 1 and 2 are correct. All C atoms form three σ bonds and the shape is trigonal planar with respect to each C in both molecules. Statement 3: Incorrect because benzene has 6 delocalised electrons in the π electron cloud. There are 2 electrons in the π bond of ethene. However, these electrons are localised between the two C atoms and not considered delocalised.