SECTION A

A1. B

A2. C

A3. A

A4. D

A5. C

A6. B

A7. A

A8. D

A9. A

A10. B

A11. B

A12. C

A13. B

A14. D

A15. D

A16. C

A17. C

A18. C

A19. D

A20. B

SECTION B

B1. (a) (i) Laboratory rules are important because they ensure safety. Following the correct procedures prevents accidents and injuries, and minimizes the risk of dangerous chemical reactions or exposures.

(ii) One importance of chemistry in our daily life is that it helps in the development of everyday products, such as medicines, cleaning agents, and materials like plastics and textiles, thus greatly improving the quality of life and contributing to the advancement of technology.

(b) (i) Candle Wax Curve: X

Reason: This is because as the wax melts, it absorbs heat without a change in temperature until it has completely turned into liquid, after which the temperature rises again.

B2. (a) If liquid P and liquid Q form mixture X and no distinct layer is seen between them, it suggests that P and Q are miscible liquids.

(b) The separation technique T used for separating two miscible liquids is likely to be distillation. Distillation is based on the differing boiling points of the liquids in the mixture.

(c) P: Ethanol, **Q:** Water

B3. (a) The number 16 represents the atomic number, which is the number of protons in the nucleus of the atom. This is unique to each element and determines the element's identity. The number 32 is the mass number, which is the sum of the number of protons and neutrons in the nucleus.

(b)(i) Since the atomic number is 16, element A is sulfur (S). Sulfur belongs to group 16 of the Periodic Table, which is also known as the chalcogen group.

(ii) As mentioned above, with the atomic number 16, element A is sulfur (S).

(c)(ii) The bonding in H2S (hydrogen sulfide) is covalent, where electrons are shared between sulfur and hydrogen atoms. In contrast, calcium oxide (CaO) involves ionic bonding, where calcium donates two electrons to oxygen, forming Ca^{2+} and O^{2-} ions that are held together by electrostatic forces.

B4. (a)

1. Prepare an aqueous solution of sodium sulfate (Na_2SO_4) in a beaker.
2. Prepare an aqueous solution of a soluble lead compound, such as lead (II) nitrate ($Pb(NO_3)_2$), in a separate beaker.
3. Slowly pour the lead (II) nitrate solution into the sodium sulfate solution while stirring.
4. Lead (II) sulfate ($PbSO_4$), which is insoluble in water, will form as a precipitate.
5. Continue stirring for a few minutes to ensure complete precipitation.
6. Let the precipitate settle, and then decant the liquid to remove as much of the supernatant as possible.
7. Filter the mixture to separate the solid lead (II) sulfate from the remaining liquid.
8. Wash the precipitate with distilled water to remove any remaining impurities.
9. Dry the filter paper with the precipitate in a warm place, like an oven or under a heat lamp, to obtain a fairly dry sample of lead (II) sulfate.

(b)(i)

Another salt that can be prepared in the same way as lead (II) sulphate is barium sulphate ($BaSO_4$). Just like the lead (II) sulphate, it can be prepared by reacting an aqueous solution of barium chloride ($BaCl_2$) with an aqueous solution of sodium sulphate (Na2SO_4). The barium sulphate will precipitate out of the solution as it is insoluble in water.

B5. (a) $2Ca(NO_3)_2 \rightarrow 2CaO + 4NO_2 + O_2$

(b) Identify the number of each type of atom in a formula unit of calcium nitrate:

- 1 calcium atom (Ca)
- 2 nitrogen atoms (N)
- 6 oxygen atoms (O), since there are two nitrate (NO3−NO3−) ions, each with three oxygen atoms.

Multiply the atomic mass of each type of atom by the number of atoms of that element in the formula unit:

- Calcium: 1×40.08 amu1×40.08amu
- Nitrogen: 2×14.01 amu2×14.01amu
- Oxygen: 6×16.00 amu6×16.00amu

Add the masses together to get the total formula mass:

- Mr= (1×40.08)+(2×14.01)+(6×16.00)amu
- Mr= 164.1 amu

(c) Calculate moles of calcium nitrate:

$Moles\ of\ Ca(NO3)2 = 164.1g/mol16.4g \approx 0.100moles$

From the balanced chemical equation, we know that 2 moles of calcium nitrate yield 1 mole of oxygen gas, so we calculate the moles of oxygen gas produced:

$Moles\ of\ O2 = 20.100moles\ of\ Ca(NO3)2 \approx 0.050moles$

Convert the moles of oxygen gas to volume at RTP (22.4 L/mol):
$Volume\ of\ O2 = 0.050moles \times 22.4L/mol \approx 1.12L$

So, from the decomposition of 16.4 g of calcium nitrate, you would expect to get approximately 1.12 liters of oxygen gas at room temperature and pressure

B6 (a) The electronic configurations given are for elements in group 18 of the periodic table, which are the noble gases. This group includes elements such as Helium (He), Neon (Ne), Argon (Ar), etc.

(b) The chemical unreactivity of noble gases is due to their electronic configurations. Each of these elements has a full valence shell, meaning they have reached a stable electronic state. Because of this stability, they have no tendency to gain or lose electrons, making them very unreactive.

(c) Assuming W refers to one of the noble gases (likely Helium or Neon due to the configuration W:2), these gases are suitable for weather balloons because they are lighter than air and non-reactive. Their lightness allows the balloons to float and reach high altitudes, and their non-reactivity ensures safety, as they won't react with other substances or ignite.

(d) As you go down group 18 of the periodic table, the density of the noble gases increases. This is because each successive element has more protons, neutrons, and electrons, leading to an overall increase in atomic mass. Since the noble gases are monatomic and the volume increase from one gas to the next is less significant than the mass increase, the density goes up.

B7 (a) $ZnCO_3(s) \rightarrow ZnO(s) + CO_2(g)$

(b) The most thermally stable carbonate in the table is potassium carbonate (K2CO3), as its mass does not change upon heating. This implies that it did not decompose under the conditions of the experiment, which would make it the most thermally stable among those listed.

(c) The environmental problem associated with the large-scale production of calcium oxide (also known as lime or quicklime) by heating calcium carbonate in a kiln is the release of carbon dioxide (CO2), a greenhouse gas that contributes to global warming.

(d) The carbonate which on heating produces a compound used as a refractory material is magnesium carbonate. Upon heating, magnesium carbonate decomposes to magnesium oxide (MgO), which is a refractory material. Refractory materials are capable of withstanding high temperatures without melting or breaking down and are used to line furnaces, kilns, incinerators, and reactors.

B8 (a) (i) For gas A, which is denser than air and soluble in water, the most suitable apparatus would be X (downward displacement) because it is designed for gases that are denser than air.

(ii) For gas B, which is less dense than air and soluble in water, the most suitable apparatus would be Y (upward displacement) since it is meant for gases that are lighter than air

(b) (i) Apparatus Z is more suitable than apparatus Y to collect gas C because gas C is insoluble in water. Apparatus Z is designed to collect gases over water, which allows gases that do not dissolve in water to be collected. Since gas C is insoluble, it will not dissolve and can be collected in the space above the water in apparatus Z.

(ii) Since gas B is soluble in water, it would not be efficiently collected by apparatus Z as it would dissolve in the water.

(c) Apparatus X is suitable for collecting gases that are denser than air. An example of a gas that could be collected using apparatus Y is carbon dioxide (CO2). Carbon dioxide is denser than air and can be collected by downward displacement of air.

B9 (a) The structural formula for ethene is C_2H_4. It consists of a double bond between the two carbon atoms and four hydrogen atoms, with each carbon atom having two hydrogen atoms attached to it.

(b) (i) Solution P is likely to be acetic acid, CH_3COOH, since the oxidation of ethanol typically results in the formation of acetic acid

(ii) Process Q is dehydration, a chemical reaction that involves the removal of a molecule of water from a substance. In the case of ethanol, dehydration usually forms ethene.

(iii) Gas R, as a product of the complete combustion of ethanol, would be carbon dioxide ($2CO_2$).

(c) The balanced chemical equation for the complete combustion of ethanol (C_2H_5OH) is: $C_2H_5OH + 3O2 \rightarrow 2CO_2 + 3H_2O$

SECTION C

C1 (a)

(i) A suitable indicator for this type of acid-base titration could be phenolphthalein.

(ii) The colour change observed with phenolphthalein would be from pink in a basic medium to colourless when the solution becomes neutral upon titration.

(b) The chemical equation for the neutralization reaction that takes place in the conical flask is: NaOH (aq) + HCl (aq)→NaCl (aq) + H_2O (l)

(c) (i) The number of moles of hydrochloric acid (HCl) used in the experiment is 0.002 moles.

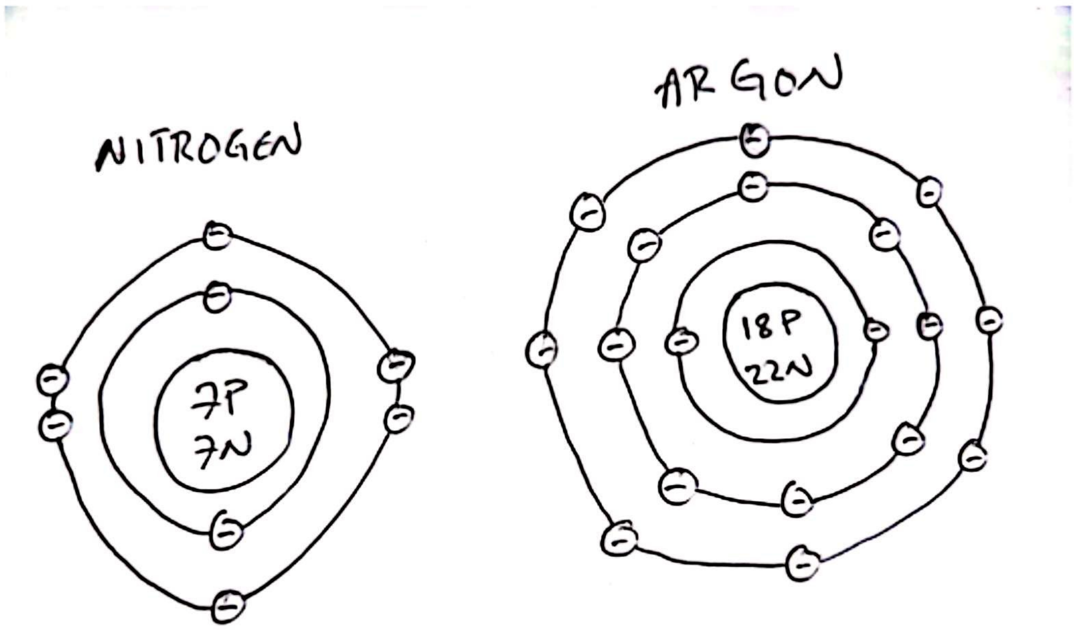
(ii) Given the 1:1 stoichiometry of the reaction, the number of moles of sodium hydroxide (NaOH) used is also 0.002 moles.

(iii) The concentration of the sodium hydroxide solution is 0.08 mol/dm^3.

(d) (i) The burette is used instead of a measuring cylinder because a burette allows for more precise measurement of the volume of the acid. Burettes have a finer scale and a stopcock that enables the titrant to be added drop by drop, allowing the end point of the titration to be determined more accurately.

(ii) To ensure exactly 25 cm^3 of sodium hydroxide was transferred into the conical flask, a pipette, which is calibrated to deliver a precise volume, is typically used. A pipette allows for more accurate measurement of liquids compared to a measuring cylinder

C2 (a)



(b) Nitrogen is found in Period 2 because it has electrons in two energy levels (1s and 2s/2p orbitals). Argon is found in Period 3 because it has electrons in three energy levels (1s, 2s/2p, and 3s/3p orbitals).

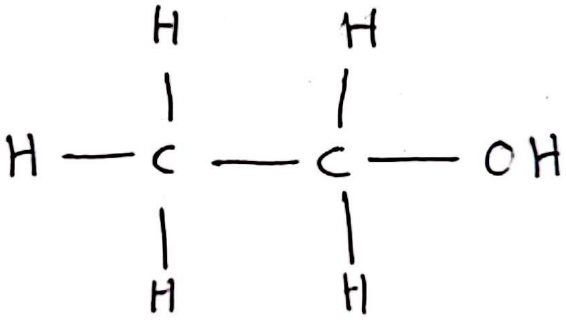
(c) (i) At point X, filtered air is cooled down to very low temperatures until it liquefies, which is known as liquefaction.

(ii) At point Y, the liquid air is allowed to warm up gradually in a distillation column, and the components of air are separated based on their boiling points. Nitrogen, which has a boiling point of -196°C, will boil off before argon, which has a boiling point of -186°C.

(d) (i) At 5°C, argon will be in a gaseous state because this temperature is well above its boiling point of -186°C.

(ii) A diagram to show the atoms of argon at 5°C would depict them spaced out, with no fixed arrangement, moving freely, indicative of the gaseous state.

C3 (a)



(b) (i) When ethanol is heated with potassium dichromate (VI), it is converted to ethanoic acid. This type of reaction is an oxidation reaction.
(ii) One safety rule to be observed when handling ethanoic acid in the laboratory is to wear appropriate safety gear such as gloves and goggles, and to handle the acid under a fume hood to avoid inhaling vapours.

(c) When ethanoic acid reacts with ethanol in the presence of a catalyst (typically sulfuric acid), the reaction is called esterification. The new substance formed is an ester, specifically ethyl ethanoate (ethyl acetate), with the molecular formula $C_4H_8O_2$.

(d) (i) Comparing the rates of reaction of ethanoic acid with sodium and with magnesium, sodium will react more vigorously than magnesium because sodium is more reactive than magnesium, as seen in the reactivity series of metals.

(ii) When aluminium is added to ethanoic acid, effervescence (bubbling) would be observed due to the liberation of hydrogen gas. This occurs because aluminium reacts with the acid to form aluminium ethanoate and hydrogen gas.

(iii) One use of aluminum based on the reaction with ethanoic acid is in antiperspirants, where aluminum compounds are used to react with the sweat to form a gel and block the sweat glands, reducing perspiration.