Metal Corrosion:

1. Describe the general physical and chemical properties of metals
    a. Most metals as grey shiny solids, except copper which is pink-brown or red-brown shiny solid (copper ions give a blue aqueous solution)

- Depends on the reactivity of the metal (more reactive metals are often less shiny due to the formation of a dull oxide layer due to oxygen in air)

2. Explain why metals are often used in the form of alloys

- Pure metals tend to be soft and malleable since the metal atoms are arranged in neat, regular rows that slide across each other easily when a force is applied
- Alloying a metal with other substances shakes it harder and stronger
    - The regular rows of metal atoms are disrupted by the presence of an atom of another size
    - Therefore, atoms no longer slide across each other as easily (harder and stronger)
- Alloy: considered a mixture of two or more metals (or with carbon)
    - Made by melting the components together and solidifying the mixture
    - Components must be soluble in each other when molten and should not separate into distinct layers when solid

3. Describe steels as alloys which are a mixture of iron with carbon or other metals and how controlled use of these additives changes the properties of the iron
4. State the uses of mild steel (car bodies, machinery) and stainless steel (chemical plant, cutlery, surgical instruments)

- Steel: mixture of iron with carbon or other metals
- Steel: properties depend on its carbon content, the heat treatment it receives, and the presence of other metals (hardness and brittleness increases when the carbon content increases
    - Addition of cobalt: highly magnetic steel used to make permanent magnets
    - Addition of tungsten: high speed steel that stays very hard at high temperatures
    - Addition of manganese: hard and tough, used in rock drills
    - Addition of silicon: spring steels
    - Addition of molybdenum: resistant to acid corrosion

Alloy	Composition	Advantages	Uses
Mild Steel	99-99.5% Fe 0.15-0.25% C	Harder and stronger than iron, more malleable and ductile; withstand great stress and strain	Construction of car bodies, machinery, and steel rods to reinforce concrete
Stainless Steel	90-95% Fe 5-10% Cr and Ni Variable% of C	Hard; resistant to corrosion; attractive in appearance	Making cutlery and surgical instruments; used in chemical plants

5. Describe the essential conditions for the corrosion (rusting) of iron in the presence of oxygen and water; prevention of rusting can be achieved by placing a barrier around the metal (painting/greasing/plastic coating/galvanizing)

Introduction to Rusting:

- When a metal reacts, its atoms become ions and the metal eventually disappears as compounds
- Corrosion: gradual destruction of any metal due to reaction with air, water or other chemicals
- Rusting: corrosion of iron, which needs both air and water (specific to iron)

    - Contact with water containing dissolved oxygen, iron atoms lose electrons (Fe^{2+})
    - $O_2 + 2H_2O \rightarrow 4e^- + 4OH^-$ (electrons transferred to oxygen and water to form hydroxide ions)
    - Presence of oxygen allows further oxidation (iron (II) oxidized to iron (III))
    - Iron (III) hydroxide changes to hydrated iron (II) oxide, which is rust

Conditions speeding up rusting:

- Water contains other dissolved ionic substances (speeds up rate of rusting)
    - Such as aqueous sodium chloride solution or dilute acids
    - Air from the sea (droplets of salt solution) and polluted air (dissolved gases like SO_2) speed up rusting
- Iron touches certain metals less reactive than iron (speeds up rate of rusting) like copper
    - In contact with copper, iron tends to lose electrons faster than copper (more reactive)
    - In presence of oxygen and water, the piece of iron loses electrons to both copper and oxygen and water (rusts even more quickly)

Prevention of Rusting:

- Application of protective layer (paint, oil, grease, plating)
    - Disadvantage: when the paint or metal layer is removed, the exposed iron will rust
- For other metals, storage in oil (sodium and potassium)

6. Describe sacrificial protection of iron by a more reactive metal in terms of the reactivity series where the more reactive metal corrodes preferentially (underwater pipes have a piece of magnesium attached to them)

- Sacrificial Protection (galvanizing)
    - Galvanized iron is covered by zinc, and zinc is more reactive than iron so zinc atoms will form zinc ions instead of iron which prevents iron from rusting
    - As long as some part of the zinc is in contact with iron, it still gives protections
        - Since both metals are conductors and movement of electrons occurs easily
- Iron pipes and magnesium
    - Magnesium atoms lose electrons more readily and magnesium will protect iron
    - Blocks of magnesium are also attached to the side of ships
- Principle: **connect the iron to another metal higher up in the reactivity series**