Appendix 1: Research Paper Questions

Instructions

For the UNSO 2023, you are required to select two subjects out of Physics, Chemistry, and Biology. Within each subject, choose 2 Research Problems to attempt. However, ensure that the two problems you choose from a subject do not come from the same topical area. For instance, if you select Physics, one problem can be from the topic Heat, and the other should be from either Light or Magnetism.

PHYSICS

1. **Topic: Light (Reflection on Curved Surfaces)**
    a. **Problem 1: Beyond Reflection - Investigating Light Refraction on Curved Surfaces:** Explore the phenomenon of light refraction on various curved surfaces, such as lenses or water droplets. Investigate how the shape and curvature of these surfaces affect the path of light and the formation of images.
    b. **Problem 2: Bending Light - Investigating the Phenomenon of Total Internal Reflection:** Explore the phenomenon of total internal reflection and its applications. Investigate the conditions and factors that lead to total internal reflection, such as the refractive indices of materials and the angle of incidence. Design experiments to measure critical angles and analyse the principles behind optical fibres and other devices utilizing total internal reflection.
2. **Topic: Heat (Heat Quantities and Vapors)**
    a. **Problem 1: Heat and Vaporization: Unveiling the Mysteries of Phase Transitions:** Investigate the relationship between heat quantities and vaporization. Explore the factors that influence the evaporation and condensation processes, such as temperature, pressure, and surface area. Analyse the energy changes associated with these phase transitions.
    b. **Problem 2: Hotter or Colder? Exploring Heat Transfer in Different Environments:** Investigate the mechanisms of heat transfer in various environments. Compare and analyse the efficiency of conduction, convection, and radiation in transferring heat energy. Explore how different materials, surface areas, and temperatures affect heat transfer rates and design practical applications for efficient thermal management.
3. **Topic: Magnetism (Electromagnetic Effects)**
    a. **Problem 1: Electromagnetic Marvels: Harnessing the Power of Magnetism:** Explore the various electromagnetic effects and their practical applications. Investigate phenomena like electromagnetic induction, magnetic fields, and the generation of electric currents. Design experiments to understand the principles behind these phenomena and their potential applications.
    b. **Problem 2: Magnetic Fields in Action: Investigating the Influence of Magnetic Fields on Electric Currents:** Study the interaction between magnetic fields and electric currents. Investigate phenomena such as electromagnetic induction, Faraday's law, and the behaviour of charged particles in magnetic fields. Design experiments to demonstrate the principles of generators, transformers, and other devices that utilize electromagnetic effects.

CHEMISTRY

1. **Topic: Carbon in the Environment**

    a. **Problem 1: Sustainable Energy Storage:** Investigate and develop new materials or technologies for sustainable energy storage, such as advanced batteries, supercapacitors, or energy-dense fuel cells, with a focus on improving efficiency and reducing environmental impact.

    b. **Problem 2: Carbon Footprint Beyond Emissions: Investigating Carbon Sequestration Methods:** Explore innovative methods for carbon sequestration and reduction in the environment. Investigate natural and artificial carbon sinks, such as forests, oceans, and carbon capture technologies. Analyse the efficiency, feasibility, and potential long-term impacts of different carbon sequestration approaches.

2. **Topic: Energy Changes During Chemical Reactions**

    a. **Problem 1: Energizing Reactions: Unravelling Energy Changes in Chemical Reactions.** Study the energy changes that occur during chemical reactions. Investigate exothermic and endothermic reactions, heat transfer mechanisms, and factors influencing reaction rates. Develop methods to measure and quantify energy changes in chemical systems.

    b. **Problem 2: Dancing with Energy: Exploring Energy Changes in Chemical Reactions:** Investigate the energy changes during chemical reactions, focusing on endothermic and exothermic processes. Explore different methods to measure and quantify energy changes, including calorimetry and bond dissociation energies. Analyse the factors that influence reaction energies and propose strategies to optimize energy usage in chemical processes.

3. **Topic: The Periodic Table**

    a. **Problem 1: Periodic Trends Unleashed: Exploring the Secrets of the Periodic Table:** Investigate the patterns and trends within the periodic table. Analyse the relationship between atomic structure, chemical properties, and periodic trends such as electronegativity, ionization energy, and atomic radius. Explore the applications of these trends in predicting chemical behaviour and properties.

    b. **Problem 2: Elements Unveiled: Investigating Unique Properties and Applications of Rare or Unusual Elements:** Choose a specific rare or unusual element from the periodic table and explore its unique properties and potential applications. Investigate its chemical reactivity, electronic structure, and physical characteristics. Analyse its potential uses in various fields, such as medicine, technology, or energy production.

BIOLOGY

1. **Topic: Nutrition in animals**

    a. **Problem 1: Fuelling the Body: Unveiling the Secrets of Animal Nutrition:** Investigate the nutritional requirements of animals and their dietary adaptations. Study the impact of different diets on growth, development, and overall health. Analyze the relationship between nutrient availability, metabolism, and the diverse physiological processes in animals.

    b. **Problem 2: Gut Microbiome: Investigating the Impact of Diet on Microbial Diversity and Human Health:** Explore the relationship between diet, gut microbiota, and human health. Investigate the effects of different diets on the composition and diversity of the gut microbiome. Analyse the potential links between gut microbiota and conditions such as obesity, immune disorders, or mental health. Propose strategies for maintaining a healthy gut microbiome through dietary interventions.

2. **Topic 2: Chemical Coordination in Humans**

    a. **Problem 1: Chemical Messengers: Understanding the Intricacies of Chemical Coordination in Humans:** Explore the endocrine system and its role in chemical coordination within the human body. Investigate the structure and function of hormones, their synthesis, secretion, and target tissues. Analyse the regulation of physiological processes and the impact of hormonal imbalances on human health.

    b. **Problem 2: Chemical Signals in Nature: Investigating Pheromones and their Role in Animal Behaviour:** Study the role of pheromones in animal communication and behaviour. Focus on a specific group of animals or species and investigate the chemical compounds involved in pheromone signalling. Analyse the effects of pheromones on mate selection, territoriality, or social behaviour. Design experiments to understand the mechanisms and functions of pheromones in the animal kingdom.

3. **Topic 3: Genetics and Monohybrid Inheritance**

    a. **Problem 1: Genetic Crossroads: Delving into Genetics and Monohybrid Inheritance:** Investigate the principles of monohybrid inheritance and explore genetic traits in different organisms. Conduct experiments involving Mendelian crosses, Punnett squares, and the analysis of inherited traits. Explore the application of genetic knowledge in areas such as selective breeding and genetic engineering.

    b. **Problem 2: From Genotype to Phenotype: Exploring the Impact of Epigenetics on Gene Expression:** Investigate the field of epigenetics and its role in gene expression and inheritance. Study epigenetic modifications such as DNA methylation and histone acetylation and their influence on gene regulation. Explore the impact of environmental factors on epigenetic changes and their potential effects on phenotypic traits. Analyze the implications of epigenetics in areas such as disease development, development biology, or personalized medicine.