Production of Materials

1. Fossil fuels provide both energy and raw materials such as ethylene, for the production of other substances

"Identify the industrial source of ethylene from the cracking of some of the fractions from the refining of petroleum"

Source/production of Ethylene:

Ethylene originates from crude oil which is obtained from biomass. Crude oil is taken to a fractional distillator and distilled to separate the large hydrocarbons from the small ones. These large hydrocarbons are then processed into catalytic cracking, which involves breakdown of large hydrocarbons into smaller ones by heating the alkane to high temperatures in presence of a catalyst (zeolite). The cracking of large hydrocarbons result in the production of ethylene

- Thermal Cracking:
  - This procedure is used to produce smaller and more industrious compounds such as ethylene
  - It involves heating alkanes to high temperatures in absence of air (Oxygen in air will cause alkanes to combust) which would break the covalent bonds between the compounds to form two new molecules
- Catalytic Cracking:
  - Same as thermal cracking but it includes a catalyst such as zeolite (alumino-silicate which has large SA), which reduces the amount of heat needed to crack molecules.

"Identify that ethylene, because of the high reactivity of its double bond, is readily transformed into many useful substances"

- Since ethylene has double carbon- carbon bonds, it is very reactive
- Most reactions of alkenes take place at the double bond
- Alkenes react with many substances to form single bonds. This process is called addition reaction.

Addition reaction: A chemical reaction in which doubled or triple covalent bonds in unsaturated hydrocarbons break down to combine with other hydrocarbons to form larger compounds. This reaction usually occurs with a presence of a catalyst

"Identify that ethylene serves as a monomer from which polymers are made"

Polymer: A long chained molecules made up of a linked series of repeated monomers (eg. Polyethylene)
Monomer: Simple compound that join up to form polymers. (eg. Ethylene)
Polymerisation: The process of making polymers by allowing monomers to link up

- Ethylene is a monomer which is catalytically cracked to from single bonded compounds which join together to form a polymer called polyethylene
- Under the influence of a catalyst, each double bond in ethylene becomes a single bond and the extra electrons form new single bonds that tie the molecules together into long chains

"Identify that polyethylene as an additional polymer and explain the meaning of this term"

Additional polymer: polymers made by adding double bonded molecules to each other, resulting in no other products, under the presence of a catalyst.

- Eg. Polystyrene, PVC, polyethylene

Additional polymerisation: When unsaturated monomers combine by the breakdown of double or triple bonded covalent bonds to form a polymer

"Outline the steps in the production of polyethylene as an example of a commercially and industrially important polymer"

The steps take to produce polyethylene form ethylene:

1. Initiation: Under extreme heat and the presence of a catalyst, the double bonds in ethylene break down and become very reactive
2. Propagation: groups of reactive ethylene join together in a head to tail like arrangement
3. Termination: When sufficient monomers are linked, the process ends by allowing two hydrogen molecules to join at each ends of the polymer

- When ethylene has been converted to polyethylene, it is often made into plastics.
- There are two types of polyethylene, which is industriously used

Low Density Polyethylene (LDPE)
Properties: Low density, flexible, soft
These are polymers which consist of branched chains. Since they are branched, they are moved further apart and therefore have lower density. This also results in weaker dispersion forces. All these properties cause LDPE to be soft and flexible
Uses: Garbage bags, glad wrap, plastic squeeze bottles, electrical insulation

High Density Polyethylene (HDPE)
Properties: Dense, hard, and rigid
These are polymers which consist of unbranched chains, or straight chains. Since they are straight, they can be closely packed together, creating greater density. This in turn creates stronger dispersion forces. This causes HDPE to be hard and rigid.
Uses: toys, rubbish bins, boats, canoes, buoys

"Identify the following as commercially significant monomers: Vinyl Chloride, Styrene by both their systematic and common names"

- Vinyl Chloride (Chloroethylene C_2H_3Cl) is an unsaturated monomer which combines to form the polymer Polyvinyl Chloride (PVC systematic name: polychloroethene)
  - PVC is thermoplastic, since it is branched.
  - The chlorine group is attached to every second carbon atom
  - PVC is used in piping, gutters, credit cards
- Styrene (ethenylbenzene) is also an unsaturated monomer which combines to form Polystyrene (systematic name: polyphenylethene)
  - The phenyl/Benzene group is attached to every second carbon atom
  - Polystyrene is often turned into Styrofoam by blowing gases through it while it is at high temperatures and is liquid.
  - Styrofoam is used in packaging, container, cups, insulation, and beam bags.

"Describe the use of the polymers made from the monomers (styrene, vinyl chloride) in terms of their properties"
Poly Vinyl Chloride:
Uses: Electrical insulation, piping, garden hoses, packaging material (good shock absorbers)
Properties: It is a good electrical/heat insulator, is stiff and rigid due to the Cl side group, it is a good shock absorber, has fire retardant properties
Polystyrene:
Uses: Foam cups, toys, CD cases, insulation
Properties: is a good electrical and heat insulator since it has no free electrons to conduct electricity. Is very stiff strong and rigid due to the large phenyl/ethyl side group, therefore can be used to make toys, screwdriver handles etc. It can be turned into low density Styrofoam by blowing air molecules through it.

- The properties of polymers are determined by the following characteristics:
  - Chain length (molecular weight)
    - Longer chain $\Rightarrow$ higher MP $\Rightarrow$ harder substance
  - Length of branch
    - Unbranched chains are more dense than branched
    - Less branching $\Rightarrow$ higher density $\Rightarrow$ harder substance
    - More branching $\Rightarrow$ more flexible
  - Presence of side groups
    - Presence of large side groups such as benzene ring in polystyrene, reduces the flexibility of the substance, causing it to be more rigid
      - Chain stiffening: Putting a side group into a linear chain to reduce flexibility and to cause rigidity and stiffness
  - Interactions between chains

- When long linear chains align themselves so that they lie parallel to each other, there is an interaction between the chains (cross linking). The most common interaction is hydrogen bonding. This increases the rigidity

"Identify data, plan and perform a first hand investigation to compare the reactivities of appropriate alkenes with the corresponding alkanes in bromine water"

Sample response: Justify the procedure you used to compare the reactivities of an alkane and its corresponding alkene. Name the alkane, alkene and any reagents used. (4)

Justify means to support an argument, ie why you used whatever you used

To compare the reactivities of an alkane and an alkene, a bromine test was used.

The alkane used in the procedure was cyclohexane and the corresponding alkene was cyclohexene.
Justification: The reason for these choices was because they exist as liquids at room temperature, hence they are easier to handle than gases, and they only vary by a double bond, so other variables will not influence the results.
The chemical used to test was bromine water, since it will react with a double bond but not single bonds

2mls of yellow bromine water was added to one test tube containing cyclohexane, and another with cyclohexene and was gently shaken. All variables in both tubes such as volume and temperature was kept constant

The both test tubes contained two layers: a lower aqueous layer and an upper organic layer.
In the tube containing cyclohexane, the lower layer stayed yellow-orange whereas in the cyclohexane tube, this layer turned colourless.

The decolourisation of either chemicals indicated the presence of unsaturated hydrocarbons; hence the chemical was identified as an alkene.

Sample response: During your study of this module, you carried out an investigation to compare the reactivities of alkanes and their corresponding alkenes in bromine water.

a. Describe the experiment you performed (2)
b. Explain the results of your investigation (3)
c. Justify the selection of the chemical substances chosen for this investigation (2)

a. The experiment we performed was the bromine test.
   2mls of yellow bromine water was added to one test tube containing cyclohexane, and another with cyclohexene and was gently shaken. All variables in both tubes such as volume and temperature were kept constant. We recorded any colour changes we could see in any of the test tubes
b. The cyclohexane did not react with the bromine water while the cyclohexene did. We could tell this was so because of the decolourising of solution. The halogen (bromine) added with the unsaturated alkene (cyclohexene), which is reactive and hence the solution decolourised as colourless forming 1,2-dibromo-alkene.
   The alkane (cyclohexane) on the other hand is more unreactive, since it is already saturated, therefore does not react with the bromine and so there is no decolourisation.
c. The alkane used in the procedure was cyclohexane and the corresponding alkene was cyclohexene.
   Justification: The reason for these choices was because they exist as liquids at room temperature, hence they are easier to handle than gases, and it was necessary to select liquids in order to observe the colour changes upon addition of bromine water.
   The chemical used to test was bromine water, since it will react with a double bond but not single bonds

"Analyse information from secondary sources such as computer simulations, molecular model kits or multimedia resources to model the polymerization process"

Sample response: Justify the appropriateness of using sources such as computer simulations and molecular model kits to model the polymerization process (6)
General statement: The use of secondary sources such as computer simulations and molecular modeling kits is appropriate to the study of polymerization.
Main Features: Computer simulations allow one to see the relationship between the structure of the monomer and the structure of the polymer and where bonds are broken and formed, showing the spatial relationships of the various atoms and bonds. Computer simulations allow bond angles to be accurately portrayed and the molecules to be rotated and altered quickly.

Molecular models allow a 3 dimensional understanding of the shapes of the molecules, which cannot be gained from pen and paper equation writing. Molecular models allow rotation about the bonds. It is extremely important to understand these relationships by using models, as it is not possible to view the molecules directly, even using the most high-powered microscope, and bonding its integral to many of the properties of molecules

Discuss the advantages of using models in chemistry. Use examples to illustrate your answer (6) (CSSA 2002)
Models can be used to show how monomers are linked to form polymers, they can be used to simulate the movement of the electrons during bond-breaking and bond-forming or the movement of protons during acid-base reactions particularly to distinguish between the ionization of strong and weak acids. Models also give an indication of which atoms are joined to which and the general shape of the molecule is understood, to help in the understanding of isomers. They are used to visualize what is happening at the atomic or subatomic levels. Models, however are not to scale so they can only be used to give general ideas, not accurately measured information

2. Some scientists research the extraction of materials from biomass to reduce our dependence on fossil fuels
"Discuss the need for alternative sources of the compounds presently obtained from the petrochemical industry"
General Statement: In the future, there is a need for alternative sources for petrochemicals, since it is a non renewable resource and the burning of petrochemicals releases pollutants into the atmosphere threatening living life in the biosphere.

Issue 1: Limited resources
Many people use petrochemicals, such as fossil fuels as a source of energy to improve their quality of life. At the present time, the raw materials for making compounds in the petrochemical industry come from crude oil which is a non renewable resource, meaning that eventually it will run out. The accumulation of biomass takes hundreds of millions of years and our petroleum and gas reserves have only around maximum 100 years availability. Therefore to meet our needs of energy production, an alternative source of petrochemicals are required.

Issue 2: Environmental issues
The burning of petrochemicals such as fossil fuels releases toxins and pollutants into our atmosphere which poses threat to our natural environment.
Currently there is an increasing burning of fossil fuels, such as in motor vehicles and nuclear reactors as means to provide energy. The combustion of fossil fuels releases pollutants such as sulfur dioxide and oxides of nitrogen into our atmosphere which may lead to devastating effects such as global warming, acid rain and photochemical smog, endangering all life form on earth.
If our increasing use of petrochemicals is not restricted, or alternative sources not found, then we are in danger of damaging living organisms in nature and our own health.

Conclusion:

Although there are great needs for petrochemical derived compounds due to its benefits, the effects of its use are very problematic. There is a need for an alternative resource to replace our petrochemical derived compounds.

"Explain what is meant by a condensation polymer"

Condensation polymer: Polymers formed by the joining of monomers which eliminates a small molecule such as water.

Since condensation reactions eliminate a small molecule, condensation polymers do not contain all the atoms that were initially present in the monomer, therefore it is different to additional polymers

"Describe the reaction involved when a condensation polymer is formed"

Condensation Polymers are formed when monomers such as beta glucose polymerize together through the reaction between the OH groups. The OH groups in 2 glucose molecules break and eliminate a water molecule. The remaining oxygen group links up the monomers forming a long chain

"Describe the structure of cellulose and identify it as an example of a condensation polymer found as a major component of biomass"

Biomass: All organic materials produced by living organisms such as plants, which have been compressed through time and is used to create crude oil.

Recognize: Cellulose (condensation polymer) is a major component of plants and is the most abundant molecule in living tissues making around 50% of total organic carbon in biosphere

- Cellulose is a biopolymer made up of beta-glucose monomers
  - The formula for glucose is $HO\text{-}C_6H_{12}O_6\text{-}OH$. In the HO-OH group water is eliminated, leaving the O- only, which bonds onto more glucose monomers to form a cellulose

Difference between α-glucose monomers and β-glucose:

- α-glucose has both hydroxyl groups (OH) pointing downwards. These monomers form starch
- β-glucose has one hydroxyl group pointing downwards and the other upwards. These monomers form cellulose

Formation of cellulose:

The β-glucose monomers align themselves to form a linear structure. When the glucose condenses, the hydroxyl group on one side of the monomer is removed and the hydrogen from the other hydroxyl group is removed to form the eliminated molecule, water. The monomers then join up with the oxygen joining the sides of each monomer such that every second monomer is inverted (refer to a diagram)

N.B: Memorise the simplified structure of α and β glucose monomers!!

"Identify that cellulose contains the basic carbon-chain structure needed to build petrochemicals and discuss its potential as a raw material"

Recognize: Cellulose is made up of glucose monomers which contain a carbon chain structure and are held by strong hydrogen bonding. It can be used to produce ethylene

General statement:

There is a high potential for cellulose to be raw materials for the production of petrochemicals.

Cellulose can be decomposed into glucose units which contain the basic carbon chain structures needed to build petrochemicals currently being used in society today.

Flow chart:

$$cellulose \xrightarrow{Decomposition} glucose \xrightarrow{Fermentation} ethanol \xrightarrow{Dehydration} ethylene \xrightarrow{addition} monomers \longrightarrow polymers$$

Advantage 1: Environmental Impacts

Furthermore, cellulose is biodegradable, meaning that it is environmentally friendly.

Advantage 2: Reduces dependence on non-renewable resources

The fact that it also is a renewable resource also increases the potential of cellulose being a source of alkenes needed as a starting point for the manufacture of polymers.

Disadvantage 1: Extraction difficulty

Despite such potential, cellulose has not been used as a source of these chemicals because there is no efficient method of converting cellulose to glucose at a large scale. Hence ethanol and ethylene is difficult to obtain.

Disadvantage 2: Environmental impacts

Moreover, in order to grow vegetation suitable for the extraction of cellulose, vast areas of land is required. The clearing of land and deforestation gives rise to negative environmental effects such as land erosion and degradation, the destruction of animal habitats and salinity.

Conclusion: Judgment

Cellulose has high potentials as a raw material which will both benefit the petrochemical industry and the environment (in some respects). However our current technology restricts the process. Unless a commercially viable method of extracting glucose is discovered, cellulose will not replace petrochemicals, but rather be used as an extension, such as rayon.

"Use available evidence to gather and present data from secondary sources and analyse progress in the recent development and use of a named biopolymer. This analysis should name the specific enzyme(s) used or organism used to synthesise the material and an evaluation of the use or potential use of the polymer produced related to its properties"

Introduction: Biopolymers are naturally occurring polymers. One example of a biopolymer is polyhydroxybutanoate (BHP), a stiff and brittle plastic Polyhydroxybutanoate (PHB)

How Biopolymer is produced:

PHB was first produced in 1925 in a lab when a certain type of micro-organism named Alcaligenes Eutrophus was fed a particular nutrient, which allowed this bacteria to multiply into large colonies. By restricting the nutrient, the bacterium was unable to reproduce and so instead, it stored its contained nutrients in the form of PHB. The bacterium was then harvested and PHB extracted.
Through time, scientists have discovered improved techniques in extracting PHB. By genetically modifying crops such as corn with the PHB gene, a greater amount of the polymer was able to be extracted.

Properties of Biopolymer:

PHB is used in a variety of ways due to its useful properties- it is biodegradable, renewable and non toxic. Some of its uses include disposable nappies, bottles, packages and containers

Potential use of Biopolymer:

Since PHB is a renewable resource and possess useful properties, it has high potential of being used for a variety of purposes, even in the medical field (such as medical sutures) due to it being non-toxic and biodegradable.
While PHB wouldn't be economic for plastics that should be non-biodegradable, such as for piping, it would be potentially successful in the use of plastic bags and containers since it is environmentally friendly.

Judgment/Conclusion:

PHB has high potential for abundant use in the future if a commercially viable method of production is found, while still maintaining its useful properties in the compound.

3. Other resources, such as ethanol are readily available from renewable resources such as plants

"Describe the dehydration of ethanol to ethylene and identify the need for a catalyst in this process and the catalyst used"

Ethylene can be produced from ethanol by dehydrating it in the presence of concentrated sulfuric acid (H_2SO_4) as a catalyst.

When ethanol is heated with the presence of sulfuric acid, the OH group and the adjacent H atom is lost and converted to water. The remaining compound turns into ethylene

$$C_2H_5OH \xrightarrow{Conc.H_2SO_4+heat} C_2H_4 + H_2O$$

"Describe the addition of water to ethylene resulting in the production of ethanol and identify the need for a catalyst in this process and the catalyst used"

The above reaction can be reversed. By adding water and ethylene (hydrating ethylene) and heating it with sulfuric acid as a catalyst, ethanol is produced

$$C_2H_4 + H_2O \xrightarrow{dilute.H_2SO_4+heat} C_2H_5OH$$

The reason why a catalyst is required is because the water molecule itself cannot break the double bond of ethene.

"Describe and account for the many uses of ethanol as a solvent for polar and non-polar substances"

General statement: Ethanol is the second most important solvent, due to its effective dissolving properties.
Uses as solvents: It is used in cleaning agents, antiseptics, medicines, perfumes and many other chemicals.

Reasons for/explanation:
Ethanol is a good solvent due to the presence of the OH group. The large electronegativity between the oxygen and hydrogen atom, in the OH group, creates polarity in the molecule. Therefore, ethanol has the ability to attract other polar molecules, such as water. Often ethanol forms strong hydrogen bonds with other polar molecules, and this attraction dissolves polar substances.

Ethanol also has the ability to dissolve non-polar substances, such as oil since it has a non-polar ethyl group ($-C_2H_5$). This ethyl group experiences dispersion forces and since other non-polar substances posses dispersion forces, the interactions between the molecules allow dissolving to take place, as expressed by the rule "like dissolves like".

"Outline the use of ethanol as a fuel and explain why it can be called a renewable resource"

Uses as fuels: Ethanol is blended into petrol and is used to fuel cars. Ethanol is also used as portable fuel in camping stoves.

Ethanol as renewable resource:
Ethanol is considered a renewable resource since it is obtained from glucose which is present in plants and they are a renewable resource. Furthermore, when it undergoes combustion, the products released are water and carbon dioxide which are naturally occurring liquids and gases.

$$C_2H_5OH(l) + 3O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(l)$$

The released carbon dioxide is absorbed by plants for photosynthesis, therefore returning back to the carbon cycle in nature.
Since ethanol is obtained naturally and returns naturally into nature to be "recycled", it is considered a renewable resource.

"Describe conditions under which fermentation of sugars is promoted"

Enzyme: A biological catalyst, used to turn glucose into ethanol. Example of enzyme is zymase.
In fermentation, glucose is converted to ethanol and carbon dioxide by enzymes in yeast cells called zymase

Conditions under which fermentation of sugars is promoted

- Grain mashed up in water
- Addition of yeast (catalyst)
- Anaerobic conditions
- Kept under warm temperature of 37 degrees (blood temp)
  - This is because zymase is sensitive to temperature

$$C_6H_{12}O_6 \xrightarrow{zymase(catalyst)} 2C_2H_5OH + 2CO_2$$

(Must memorise)

Model response: "Describe conditions under which fermentation of sugars is promoted"

Fermentation may be promoted by keeping the environment in anaerobic conditions, (ie absence of oxygen) and at a warm temperature, preferably around 37 degrees Celsius. The solution must have an addition of zymase (in yeast cells) in order to catalyse the reaction. For best results of fermentation, it is ideal to mash up the grains (which contain glucose) and mix with water.

"Process information from secondary sources to summarise the process involved in the industrial production of ethanol from sugar cane"

- Industrially, ethanol is fermented from sugar cane. The enzymes (fungi starch) first convert starch or sugar from the mixture of sugar canes into glucose. Then bacteria is used to ferment glucose into ethanol

$$C_{12}H_{22}O_{11} + H_2O \rightarrow 2C_6H_{12}O_6 \rightarrow 4C_2H_5OH + 4CO_2$$

- Summary of industrial process of producing ethanol from sugar cane:
  - Organic biomass (sugar cane) is crushed and hydrolised (added water) with dilute sulfuric acid to break cellulose bonds and from glucose molecules
  - Solid cellulose residue is filtered and sugar solution (with glucose) is obtained. The cellulose residue is further broken down with acids and then neutralised
  - The sugar solution is fermented with bacteria or yeast to produce ethanol (very little amount, 15%) and carbon dioxide gas
  - The ethanol is distilled from the sugar solution to get a higher concentration

"Summarise the chemistry of the fermentation process"

Fermentation occurs when a sugar solution is added yeast and a reaction is allowed to take place in an anaerobic and warm condition at 37 degrees.

$$C_6H_{12}O_6 \xrightarrow{zymase(catalyst)} 2C_2H_5OH + 2CO_2$$

Additional information:

- The yeast yields about 15% ethanol, the alcohol concentration at this level kills this yeast, therefore not allowing any more ethanol to produce from glucose
- The ethanol is extracted from the aqueous mixture of ethanol and other substances by using fractional distillation

"Define the molar heat of combustion of a compound and calculate the value for ethanol from first hand data"

Molar heat of combustion: ***The heat energy, in joules or kilojoules, released by the complete combustion of 1 mole of a fuel.***

$$\Delta H = mC\Delta T$$

"Asses the potential of ethanol as an alternative fuel and discuss the advantages and disadvantages of its use"

Introduction: At the present time, the potential of ethanol being an alternative fuel is not viable. Methods of producing ethanol are very expensive compared to the price of obtaining petrochemicals from non-renewable crude oil. However, as supplies of fossil fuels dwindle and/or taxes are imposed on their use, or if cheaper alternative methods of extracting ethanol from biological sources are found, then ethanol has a high potential of becoming a possible fuel substitute.

Advantages:

Ethanol can be produced by two methods. The common method is by additionally reacting water with ethylene.

$$C_2H_4(g) + H_2O(g) \xrightarrow{dil.H_2SO_4} C_2H_5OH(l)$$

The main advantage of ethanol as a fuel produced this way is that it produces a much cleaner burn when combusted, and so does not pose a significant threat to the environment, as petrol.

However, compared to petrol, producing ethanol through this method required greater amounts of energy, hence is more costly. Furthermore, the ethanol produced is less efficient than petrol since it does not produce as much energy per gram when combusted.

The second method of producing ethanol is through the fermentation of glucose. Ethanol obtained this way is seen as a more "greener" fuel.

$$C_6H_{12}O_6(aq) \xrightarrow{zymase(catalyst)} 2C_2H_5OH(l) + 2CO_2(g)$$

The production of ethanol through this method does not use any non-renewable sources, therefore our concerns and dependence on our diminishing fossil fuel supplies may be reduced. Moreover, the burning of ethanol is environmentally friendly, since the CO_2 emitted returns back to the carbon cycle in nature, by being absorbed by plants for photosynthesis.

Disadvantages:

On the other hand, growing sugar cane to obtain glucose for fermentation requires vast areas of land. Therefore, large areas of the natural environment must be cleared, giving rise to deforestation (also resulting in the loss of animal habitat), land degradation, salinity, erosion and other devastating environmental impacts.

In addition, the energy requirements for the production of ethanol through mass production of plants are much greater than the energy for which it provides. Energy inputs (which are greenhouse unfriendly) for mechanical planting, harvesting and more importantly the energy required to distill the ethanol from the fermented mixture is very high. The resulting wastes from large fermentation plants are extensive and difficult to dispose.

Conclusion:

Our current technology for producing ethanol through non-renewable resources is inefficient. If an economical and commercially viable method of converting cellulose to ethanol is found, ethanol has a high potential as an alternative fuel but in the mean time, the disadvantages of using ethanol as a direct substitute for petrol far outweigh the advantages.

Additional information:

- ***Advantages of using ethanol as a fuel alternative:***
  - Ethanol produces high quality, low cost octane. It combusts more fully, boosting octane rating in petrol. (P5 Booklet: Production of materials 5)
  - Ethanol has lower ignition temperatures therefore allows combustion at lower temperatures
  - It is a renewable resource
  - Reduces our dependence on non-renewable fossil fuels
  - Reduction of greenhouse gases since there are more complete combustions creating carbon dioxide as products instead of carbon monoxide, which is a greenhouse gas, therefore cleaner air (Refer to equations, and the oxygen to fuel ratio comparisons between ethanol and petrol)
  - Less toxic than gasoline and does not pose a severe threat to the environment if in an event of a spill
  - Works as a solvent to clean engine
    - Since ethanol is a polar and non polar solvent, it dissolves gummy deposits on engines, cleaning it
  - Ethanol is much more safe than petrol since it has a higher flash point
- ***Disadvantages of ethanol as a fuel alternative:***
  - Petrol engines are designed for octane not ethanol therefore damages engine, so therefore need modification

- Ethanol causes corrosion of fuel lines, in car engines since it is a polar molecule and water molecules attach onto it entering into car systems
- Large areas of land are required for production of ethanol
  - Land is cleared for sugar farms therefore more environmental problems such as salinity, erosion and deforestation
- The energy requirements for the production of ethanol through mass production of plants and distillation are greater than the energy which it provides.
- High costs for distilling ethanol
- Large waste products are formed from fermentation since only 15% of ethanol is produced. The disposal of this waste is another problem

"Process information from secondary sources to summarise the process involved in the industrial production of ethanol from sugar cane"

Molasses, obtained from sugar cane have high sucrose content. The molasses are mixed with water to allow sucrose to react with water to produce glucose and fructose:

$$C_{12}H_{22}O_{11}(aq)_{(sucrose)} + H_2O(l) \longrightarrow C_6H_{12}O_6(aq)_{(glucose)} + C_6H_{12}O_6(aq)_{(fructose)}$$

The glucose and fructose obtained is then allowed to ferment under fermentation conditions to produce ethanol and carbon dioxide

$$C_6H_{12}O_6(aq) \xrightarrow{zymase(catalyst)} 2C_2H_5OH(l) + 2CO_2(g)$$

"Process information from secondary sources to summarise the use of ethanol as an alternative car fuel, evaluating the success of current usage"

General statement: There are many countries around the world who have adapted to the use of ethanol as an alternative car fuel.

Main features: Countries like Brazil, which experience high pollution levels, have been quick to adopt ethanol as a substitute fuel and reports have proved to be efficient.

Meanwhile, countries such as USA and Canada only blend up to 10-12% of ethanol in their petrol and gases.

Other countries such as Australia have been slow in adopt the use of ethanol as an alternative car fuel since it is not cost effective at the present time. Furthermore, the cost of modification of engines to suit ethanol as a fuel is too great.

Judgement: Unless a cost effective method of converting cellulose to ethanol is discovered, ethanol will not be used as an alternative fuel but rather an extension.

"Identify the IUPAC nomenclature for straight-chained alkanols from C1 to C8"

In order to name an alcohol, follow the following steps:

- Determine the longest chain, which includes the OH group, the lowest possible number is assigned for the carbon bearing the OH group.
- Give the name of alkanols for the longest chain, eg pentanol (for 5), methanol (for 1) etc
- For branched alkanes, name according prefix, eg. Ethyl (for 2 carbon branched).
- $x - di/tri$ halogen $- x -$ di/tri prefix(thyl) - x - alkanol

4. Oxidation- reduction reactions are increasingly important as a source of energy

"Explain the displacement of metals from solution in terms of transfer of electrons"

Oxidation: loss of electrons

Reduction: gain of electrons

In a displacement reaction (definition next dot point), the more active metal will oxidize and loose electrons to form an ion in an aqueous solution. The less reactive aqueous metal in ion form (deficient of electrons), will gain the electrons lost by the more active metal and become neutral, forming an elemental metal.

eg. $Zn(s) + CuSO_4(aq) \rightarrow Cu(s) + ZnSO_4(aq)$

Oxidation: $Zn(s) \rightarrow Zn^{2+}(aq) + 2e$

Reduction: $Cu^{2+}(aq) + 2e \rightarrow Cu(s)$

Zinc loses electrons and displaces copper since it is more reactive than copper (refer to activity series)

"Identify the relationship between displacement of metal ions in solution by other metals to the relative activity of metals"

Displacement reaction: **Reaction in which the atoms or ions in one substance takes the place of another in a compound.**

***A r*eaction which a metal converts the ion of another metal to a neutral atom.**

$$A + BC \rightarrow AC + B$$

- **Active metals will displace less active metal ions from solution**
- **The more reactive metal will ionize from neutral state and cause the less reactive metal ions in solution to become neutral and often form solids**
- **eg.** $Zn(s) + CuSO_4(aq) \rightarrow Cu(s) + ZnSO_4(aq)$
  - **In this equation, the zinc displaces the copper since it is more reactive. The zinc solid turns into an ion by losing electrons** $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$ **and copper ion turns into a solid by gaining electrons** $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$
  - **For this equation, zinc is oxidized and copper is reduced**
- **A metal will displace another only if it is more reactive than the other.**
- ***Activity series:* Li, K, Ba, Sr, Ca, Na, Mg, Al, Mn, Zn, Cr, Fe, Ni, Sn, Pb, H_2, Sb, Cu, Hg, Ag, Pd, Pt, Au**
- **The most reactive metals displace hydrogen from water. The metals below hydrogen in the activity series do not displace hydrogen**

"Account for changes in the oxidation state of species in terms of their loss or gain of electrons"

Oxidation state: **the valence or charge of an atom, molecule or ion.**

- **The more positively charged an ion is the higher the oxidation state. Similarly the more deficiency of electrons, the increase in oxidation state.**
- **The oxidation state decreases when electrons are gained (therefore reduced)**
- **Metals in elemental form have a zero oxidations state**

Oxidant/Oxidizing agent: **An atom, molecule or ion that causes another substance to lose electrons (oxidize) as it is itself gaining electrons**

Reductant/Reducing agent: **An atom, molecule or ion that causes another substance to gain electrons (reduce) while it is itself losing electrons.**

The oxidizing agent is always reduced and the reducing agent is always oxidized. They both occur simultaneously

"Describe and explain galvanic cells in terms of oxidation/reduction reactions"

Galvanic Cell: **Electrical energy generated by a spontaneous oxidation reduction reaction and the transfer of electrons through an external conductor**

Electrolyte: **Medium in which ions can flow**

Constituents: **A galvanic cell consists of two half cells, each containing an electrode in an electrolyte (solution). One half cell (beaker with electrode) allows oxidation to take place, the other allows reduction**

Cause and effect (detailed): **Redox reactions occur when there is a direct transfer of electrons from the Reductant and the oxidant. In a galvanic cell, however, the half reactions are physically separated so that when oxidation takes place, reduction won't occur simultaneously (directly) but rather, the electrons lost from oxidation travels through an external conducting wire to the other half of the cell (the reduction electrode). This way, the electrical energy may be usable**

For example, a half cell consists of a zinc electrode placed in a zinc sulfate solution. The zinc atoms (from electrode) convert into zinc ions and dissolve in the zinc sulfate solution (electrolyte) releasing two electrons per atom

$$Zn(s) \rightarrow Zn^{2+}(aq) + 2e$$

The electrons lost travel up the external conductor (wire) and through to the other half cell. This cell consists of a copper electrode placed in a copper sulfate solution. Since this electrode gains 2 electrons, the copper ions in solution receive it and turn into atoms, attaching itself to the electrode

$$Cu^{2+}(aq) + 2e \rightarrow Cu(s)$$

In this galvanic cell, the zinc electrode is the oxidation and copper electrode is the reduction since zinc is more reactive than copper and the more reactive displaces the less reactive. (refer to ionization potentials)

Ie. More reactive metals are the Anode, Less reactive metals are the cathode

Since the zinc half cell keeps losing electrons, it becomes positively charged, and since the copper half cell keeps gaining electrons, it becomes negatively charged. To compensate for the charges and to keep neutrality between the half cells, a salt bridge is used. The salt bridge is a filter paper saturated with KNO_3 solution.

The negative sulfate ions from the copper sulfate solution move through the salt bridge to the positive zinc half cell and neutralize the charge (zinc is positive since it continually loses electrons). Similarly, the positive zinc ions migrate to the negatively charged copper half cell (copper half cell continually gain electrons), neutralizing it.

As the positive zinc ions move through the salt bridge, it pushes the K^+ ions to the negative half cell, neutralizing it. Similarly, as the negative sulfate ions from the copper electrode move through the salt bridge, it pushes the NO_3^- into the positively charged zinc half cell, neutralizing it. The ions move back and forth in the salt bridge

Physical changes seen in the galvanic cell during reaction:

- Colour of copper ions (at the cathode cell) change since the copper ions turn to solids
- Colour of anode cell electrolytes would change since zinc metals turn to zinc ions
- The zinc anode reduces in size since the zinc atoms turn to ions and dissolve in the electrolyte
- The copper cathode grows in size since the copper ions become atoms at attach onto the electrode
- Since electrons complete a circuit, current will flow and a galvanometer or voltmeter will give a reading. Or perhaps a light bulb (if present) will light up

More reactive metals have the tendency to oxidize, and so it the anode.
Less reactive metals gain electrons (reduce) and so it is the cathode.

$$\text{more reactive metals} \rightarrow \text{oxidise} \rightarrow \therefore \text{anode (negative)}$$

$$\text{less reactive metals} \rightarrow \text{reduce} \rightarrow \therefore \text{cathode (positive)}$$

Quick memory: More reactive metal release electrons therefore negative therefore anode

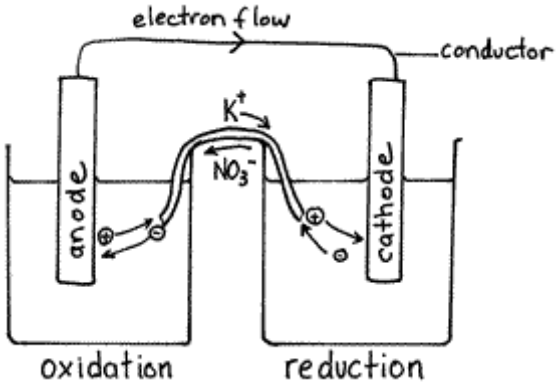
Anode = **Ox**idation
Cathode = **Red**uction

Quick memory: An Ox; Red Cat

"Outline the construction of galvanic cells and trace the direction of electron flow"

- The galvanic cell consists of two half cells and two **electrodes**. The first half cell holds an **anode** and the other half cell holds the **cathode**. Both electrodes are dunked in an **electrolyte**. The external conducting wire allows the electrons lost from the anode to be transported to the cathode. Between the cells is a **salt bridge**. This saturated electrolyte filter paper keeps neutrality between the cells.
- At the **A**node, **O**xidation occurs (loss of e) (vowels)

- At the **C**athode, **R**eduction occurs (gain of e) (consonants)



"Define the terms anode, cathode, electrode and electrolyte to describe galvanic cells"

- *Anode:* The negative electrode. Oxidation takes place in this electrode
- *Cathode:* The positive electrode. Reduction takes place
- *Electrode:* Metal strip. Surface where electrons are exchanged
- *Electrolyte:* Medium through which ions can flow. Often an aqueous solution and conducts electricity
- *Half Cell:* Metal strip in an electrolyte solution

"Perform a first hand investigation and gather first hand information to measure the difference in potential of different combinations of metals in an electrolyte solution"

Sample response: Electrochemical methods are important in producing materials and making energy available. Design an investigation to gather first hand data to measure the difference in potential of different combinations of metals in an electrolyte solution. (STANSW 2001 Trial) (5)

To measure the electrical potential of different combinations of metals in an electrolyte solution the following equipment is needed: 1M solutions of salts of copper, iron, lead, magnesium, nickel, tin, zinc; electrodes of copper lead, magnesium, nickel, tin, zinc; salt bridges soaked in potassium nitrate solution; a voltmeter; beakers and electrical leads

Method: Clean all metal electrodes to ensure they are free of coatings. Attach a copper electrode to the positive terminal of the voltmeter using an electrical lead. Attach a magnesium electrode to the negative terminal of the voltmeter using an electrical lead. Half-fill one beaker with the solution of copper salt, half fill another beaker with the solution of magnesium salt. Connect these two beakers using a salt bridge soaked in potassium nitrate. Record the maximum voltage reached. Using the copper half-cell as the reference cell, create other half-cells with the remaining metals by placing each electrode into the corresponding salt solution. Connect each other half-call in turn with the copper cell and record each maximum voltage

"Gather and present information on the structure and chemistry of a dry cell and evaluate it in comparison to one of the following: button cell, fuel cell, vanadium redox cell, lithium cell, liquid junction photovoltaic device (eg. the Gratzel cell) in terms of its chemistry, cost and practicality, impact on society, environmental impact."

The Dry Cell

- The common dry cell is a non-rechargeable galvanic cell and after use is discarded. (eg. "Eveready", "Energizer")
- *Structure and Chemistry:* (Picture page 74 Chemistry Contexts)
  - Zn | $ZnCl_2$, NH_4Cl | MnO_2, C
  - Anode (-): The outer zinc casing. The zinc oxidizes according to the following half equation:

$$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$$

- Cathode (+): The graphite rod, which is surrounded by a layer of ammonium chloride and manganese dioxide paste. The cathode <u>reduction</u> reaction is as follows:

$$2MnO_2(s) + 2NH_4^+(aq) + 2e^- \rightarrow Mn_2O_3(s) + H_2O(l) + NH_3(aq)$$

- Electrolyte: NH_4Cl and $ZnCl_2$ paste
- Overall reaction:

$$2Zn(s) + 2NH_4^+(aq) + 2MnO_2(s) \rightarrow Zn^{2+}(aq) + Mn_2O_3(s) + H_2O(l) + 2NH_3(g)$$

- *Cost and Practicality*
  - Advantages:
    - Very cheap
    - Since it is in the form of paste (rather than liquid) it is very convenient, being very transportable
    - Useful when small currents are needed
    - Small and easy to store and use
    - Maintains a steady voltage, therefore good for a range of electronic such as torches, walkman and toys
  - Disadvantages:
    - Cannot be recharged
    - Short life
    - Cannot deliver high current
    - As the zinc casing is used up through time, battery may leak
- *Impact on Society:*
  - Since it has low and constant voltage, it is used for common appliances such as torches, toys and portable radios/CDs
  - Due to its mobility, portable items, such as flashlights, could now be used, increasing the development of electrical equipments/devices.
  - The popularity of batteries have increased since its invention
- *Environmental impact:*
  - Small amounts of zinc are not problematic to the environment, however since zinc is a heavy metal, large amounts may pose a threat.
  - Manganese is also a heavy metal, disposal in large quantities are not beneficial for the environment.
  - NH_4Cl and $ZnCl_2$ paste are non toxic, so they pose little problems in dumps

<u>The Button Cell</u> (silver)

- *Structure and Chemistry:* (Picture Page 76 Chemistry Contexts)
  - Zn, ZnO | KOH (paste) | Ag_2O, Ag
  - Anode (-): Powdered zinc. The anode process is:

$$Zn(s) + 2OH^-(aq) \rightarrow Zn(OH)_2(s) + 2e^- \text{ (oxidation)}$$

  - Cathode (+): $Ag_2O(s)$ and Carbon paste. The cathode process is the <u>reduction</u> of silver oxide to solid silver:

$$Ag_2O(s) + H_2O(l) + 2e^- \rightarrow 2Ag(s) + 2OH^-(aq)$$

  - Overall Reaction: $Zn(s) + Ag_2O(s) \rightarrow ZnO(s) + 2Ag(s)$
  - Electrolyte: $KOH(aq)$ and $Zn(OH)_2(aq)$ paste
- *Cost and practicality:*
  - Since this battery is made out of silver, it is more expensive
  - Like the dry cell, it is not rechargeable
  - Can produce a significant amount of electricity
  - Provides a constant voltage over a longer period of time than the dry cell

- Its small size (and long lifespan) allows it to be used in smaller electronics such as watches and delicate equipment like hearing aids
- *Impact on Society:*
  - Its light weight, small size, long lifespan and stable voltage makes it useful for small appliances such as cameras, calculators and watches
  - Since it is non-toxic and strongly insulated, it can be used inside the body. Eg. Heart pacemakers, hearing aids
- *Environmental impacts:*
  - The expensive silver needs to be recycled
  - KOH electrolyte is caustic (corrosive) and may corrode, endangering the environment
  - Mercury residues, from mercury button cells, can cause environmental problems with unsafe disposal

"Solve problems and analyse information to calculate the potential E requirement of named electrochemical processes using tables of standard potentials and half equations"

$$E_{cell} = E_{ox} + E_{red}$$

Nuclear Chemistry provides a range of materials

"Distinguish between stable and radioactive isotopes and describe the conditions under which a nucleus is unstable"

Radioactivity: The spontaneous breakdown of an element into a new element by the emission of α, β and/or γ radiation.

Radioactive decay: the process whereby the nucleus of a radioisotope undergoes spontaneous decay

Half-life: time taken for half of a given number of radioactive nuclei to decay

- A stable isotope of an element will not emit any radiation.
- A radioactive isotope will emit radiation and decay. The emission of radiation will continue until the nucleus becomes stable.
  - By emitting radiation, the isotope's proton to neutron ratio changes.
- Elements with atomic numbers greater than 83 are naturally radioactive.
- Radioisotopes emit 3 types of radiation

Radiation	Symbol	Type	Charge	Ionizing strength	Penetrating strength
alpha	α	$^{4}He_{2}$ A helium nuclei	2+	Very high	Very low
beta	β	$^{0}e_{-1}$ An electron	1-	Medium	High
gamma	γ	high frequency electromagnetic radiation	0	None	Very high

- The stability of an isotope depends on the neutron to proton ratio. When an element has too many neutrons for the number of protons present, it becomes unstable
  - *When there are too many neutrons compared with protons* then a neutron decays to form a proton and a beta particle (a fast electron) which is emitted from the nucleus. This is **beta negative decay,** (more known as just Beta decay).

$$^{A}_{Z}X \rightarrow ^{A}_{Z+1}Y + ^{0}_{-1}e$$

  - *When there are too many protons compared with neutrons* then a proton decays to form a neutron and a positron (same mass as an electron with a positive charge). This is **beta positive decay,** (positron emission).

$$^{A}_{Z}X \rightarrow ^{A}_{Z-1}Y + ^{0}_{1}e$$

  - *When there are too many nucleons* (P&N) then **alpha decay** occurs. The loss of an alpha particle reduces the nucleus by 2 protons and 2 neutrons:

$$^{A}_{Z}X \rightarrow ^{A-4}_{Z-2}Y + ^{4}_{2}He$$

  - In gamma decay, nothing changes apart from the fact that it ends up in a lower energy state:

$$^{A}_{Z}X^{*} \rightarrow ^{A}_{Z}X + \gamma$$

Where X^{*} indicates a nucleus in an excited state

"Describe how transuranic elements are produced"

Transuranic elements: Elements with an atomic number above that of uranium i.e. Greater than 92 and don't occur naturally and only synthesized in nuclear reactors or high energy particle accelerators

- Transuranic elements are produced by:
  - bombarding natural elements with neutrons (or other particles) in nuclear reactors to produce the higher elements through radioactive decay (fission)
    - Eg. When U-238 is bombarded with neutrons it can be converted to U-239 that undergoes beta decays to produce neptunium and plutonium.

$$^{238}_{92}U + ^{1}_{0}n \rightarrow ^{239}_{92}U \rightarrow ^{239}_{93}Np + ^{0}_{-1}e$$

$$^{239}_{93}Np \rightarrow ^{239}_{94}Pu + ^{0}_{-1}e$$

  - Transuranic elements from atomic number 96 and up are all made by accelerating a small nucleus (such as He(α), B or C) in a charged particle accelerator (cyclotron) to collide with a heavy nucleus (often of a previously made transuranic element) target.
    - Eg: Curium-242 is produced by bombarding alpha particles to plutonium

$$^{239}_{94}Pu + ^{4}_{2}He \rightarrow ^{242}_{96}U + ^{1}_{0}n$$

"Describe how commercial radioisotopes are produced"

- Radioisotopes are produced by:
  - Accelerating high speed particles such as protons, deuterons (hydrogen-2 ions), helium-3 ions and alpha particles towards a target in a cyclotron.
    - Eg. Iodine 123 is produced this way, with a series of decay:

$$^{124}_{54}Xe + ^{1}_{1}p \rightarrow ^{123}_{55}Cs + 2(^{1}_{0}n)$$

$$^{123}_{55}Cs \rightarrow ^{123}_{54}Xe + ^{0}_{1}e$$

$$^{123}_{54}Xe \rightarrow ^{123}_{53}I + ^{0}_{1}e$$

  - Bombarding neutrons at a stable isotope then by undergoing a series of decay to produce another element eg:

$$^{98}_{42}Mo + ^{1}_{0}n \rightarrow ^{99}_{42}Mo$$

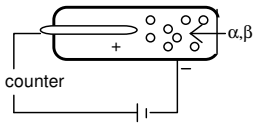
$$^{99}_{42}Mo \rightarrow ^{99}_{43}Tc + ^{0}_{-1}e$$

- Neutron rich isotopes are produced by nuclear reactors
- Neutron deficient isotopes are produced by cyclotrons (particle accelerators)

"Identify instruments and processes that can be used to detect radiation"

Radiation has the ability to ionize gases and this is the property used to detect ionizing radiation

- Photographic film:
  - The amount of radiation can be measured by the film darkening. As more radiation is exposed, the darker the film becomes.
  - The darkening is caused by the formation of silver crystals as radiation is absorbed by the silver salts in the film
- Geiger-Muller counter:
  - The GM counter is a metal tube with a with mica window at one end to allow alpha and beta particles to enter



  - Inside, it is filled with argon gas which is ionized by radiation entering it, emitting electrons. The electrons accelerate to the positive anode, and in their process they ionize more atoms in their path and create a small electric current.
  - The GM counter records the bursts of current upon each ionization and digitally displays it or converts it into audible clicks

- This device is best for detection of beta particles and can detect alpha particles if they are really close to it
- Cloud chambers:
  - These consist of a container where the radiation interacts with a cold supersaturated alcohol vapour.
  - The exposed radiation ionises molecules which cause alcohol vapour to condense to produce visible cloud tracks.
    - alpha gives straight, dense trails due to their high ionizing ability
    - beta gives lighter zigzags
    - gamma gives fainter tracks since they have low ionizing ability
- Scintillation counter:
  - This counter contains solid or liquid material whose atoms are easily excited by radiation emitting flashes of visible light
  - Radiation excites electrons in these substances (sodium iodide) causing them to jump into a higher energy level orbit. As they drop back into their usual orbit, they give off light
  - This light is detected, amplified and electronically recorded.

"Identify one use of a named radioisotope: -in industry –in medicine"
"Describe the way in which the above named industrial and medical radioisotopes are used and..."

Use of a named radioisotope in industry **Cobalt-60** (Used in the engineering industry)

- Properties of Co-60
  - It is very hard and brittle
  - Half life of 5.27 years
  - Emits gamma radiation
- Uses/Applications:

Radioisotopes such as Cobalt-60 are used industrially to detect imperfections and thicknesses of certain materials. They can detect defects in metal casting and cracks in aircraft wings, and measure the thickness of rolled sheets of plastic, paper or metal.
Beams of gamma radiation are passed through the object and are detected by the radioactive film on the other side. More radiation will pass through if there are cracks, breaks, or other flaws in the metal parts and will be recorded on the film. By studying the film, structural problems can be detected.

Use of a named radioisotope in medicine: **Technetium-99m** (Most widely used in medicine)

- Properties of Tc-99m
  - 6 hour half life: Sufficiently long enough for medical investigations and short enough to minimize patient's exposure to radiation. (Radiation leads to cancer)
  - Produces low gamma radiation which is sufficient enough to be detected by gamma ray cameras
  - Can be easily produced in reactors and is relatively cheap.
  - It can be attached to a range of biological carriers (eg. tin) and thus concentrate in a number of different types of tissues and organs
- Uses/Applications:
  - To show blood flow abnormalities, heart defects.
    - Tc-99m is attached with other substances such as tin to form compounds which attaches onto red blood cells. This is then injected into the patient's veins. The blood flow can then be traced by gamma cameras and any abnormalities in heart and blood vessels detected.
    - Tc-99m is attached onto different substances depending on the purpose of analysis eg. Brain, kidneys, bone, liver or spleen. Different substances have different chemical properties that leads to concentration in different areas of the body that is aimed for investigation
  - Reveal size and location of cancerous growth
    - Tc-99m can detect tumours such as haemoangiomas. Blood cells with Tc-99 are injected into the body and will accumulate in areas where there is cancerous growth. This detection produces an image on a scan.
  - Measure kidney function

- Tc-99 is contained within a chemical which is injected into the patient. The chemical is filtered by the patient's kidney and the radiation left inside it allows computers to detect it under gamma cameras. By comparing the kidney flow of the patient and that of a normal person, doctors can measure a person's kidney function

"...explain their use in terms of their chemical properties"

- Cobalt 60 is used because:
  - It is an emitter of gamma rays which will penetrate metal parts.
  - Co-60 has a half-life of 5.3 years and since it is in a chemically inert form, the equipment has a longer lifetime and not require regular maintenance
  - It can be reused and is not harmful once disposed since it decays to non reactive nickel.
- Technetium-99m is used because:
  - It has a very short half-life of 6 hours, which is enough time for investigations.
  - It emits low energy gamma radiation that minimizes damage to tissues but can still be detected in a person's body by a gamma ray sensitive camera
  - It is quickly eliminated from the body
  - Technetium is reasonably reactive; it can be reacted to form a compound with chemical properties that leads to concentration in the organ of interest such as the heart, liver, lungs or thyroid.

"Process information from secondary sources to describe recent discoveries of elements"

The transuranic elements with the atomic numbers above 95 (between 96 and 118) require high-energy particle accelerators to be produced. They began to be discovered in the 1940's, with others being made from high speed particles in the 50's and 60's. Element 106 was made in 1974, and elements continue to be discovered into the 80's and 90's.

- **Recent discoveries of elements**:
  - Element no.118 (Uuo Ununoctiom) was produced from the fusion of
    $^{86}_{36}\mathrm{Kr}+^{208}_{82}\mathrm{Pb}\rightarrow^{295}_{118}\mathrm{Uuo\ Ununoctiom}+^{1}_{0}n$ in 1999.
    - Krypton ion beam was accelerated by electrical and magnetic fields into lead target by team at Berkley national lab in June '99
  - Element no.166 (Uuh Ununhexium) was identified in the reaction of
    $^{248}_{96}\mathrm{Cm}+^{48}_{20}\mathrm{Ca}\rightarrow^{292}_{116}\mathrm{Uuh\ Ununhexium}+4^{1}_{0}n$

"Use available evidence to analyze benefits and problems associated with the use of radioactive isotopes in identified industries and medicine"

Radioactive isotopes in Industries:

- Advantages/Benefits:
  - Detects and traces leaks and cracks in materials such as metal. Erroneous products may be dangerous and cause serious injury
  - Creates safer and longer lasting foods
- Disadvantages/Problems:
  - Technicians and workers dealing with radioactive substances must avoid being irradiated since these substances may cause diseases such as cancer
    - Isotopes of this type that release gamma rays may affect body tissues, and kill healthy cells
  - Gases and solid radioactive wastes are produced. Radioactive gas, such as Krypton-85 is released into the air and may increases chances of lung cancer. The storage of nuclear waste for thousands of years is a problem.

Radioactive isotopes in medicine:

- Advantages/Benefits:
  - Allows treatment and tracing of medical illnesses and problems such as cancer
  - Sterilizes medical instruments. It is especially beneficial for delicate instruments
- Disadvantages/problems:
  - The production of isotopes requires nuclear reactors and accidents in operation may occur resulting in serious health problems
  - Isotopes of that release gamma rays may affect body tissues, and kill healthy cells.
    - Care must be taken in selecting and using radioisotopes so that the patient is minimized to radiation.

- Radioisotopes must have short half lives and be rapidly excreted by the body