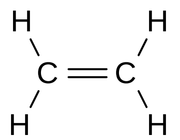
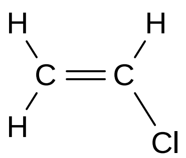
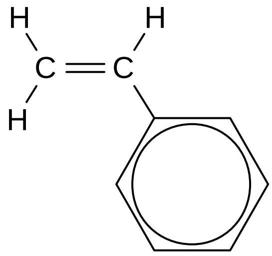
SYLLABUS REFERENCE	RELATED INFORMATION
<u>Topic 1</u> <u>Focus 1</u> **Fossil fuels provide both energy and raw materials such as ethylene, for the production of other substances.**	
• **Construct word and balanced formulae equations of chemical reactions as they are encountered.**	C_1 - Meth C_2 - Eth C_3 - Prop C_4 - But C_5 - Pent C_6 - Hex C_7 - Hept C_8 - Oct
• **Identify the industrial source of ethylene from the cracking of some of the fractions from the refining of petroleum.**	**Ethylene** is produced by the cracking *(breaking of large hydrocarbon molecules into smaller ones)* of either natural gas or crude oil, which are mixtures of hydrocarbons. There are two types; catalytic cracking and thermal cracking. **Catalytic cracking** is the process in which high molecular weight *(high BP)* fractions of crude oil are broken into lower molecular weight substances *(eg: ethylene)*. **Thermal cracking** is when a mixture of alkanes with steam is passed through very hot metal tubes *(700 to 1000°C)* and the alkanes decompose into small alkenes such as ethylene.
• **Identify that ethylene, because of the high reactivity of its double bond, is readily transformed into many useful products.**	Ethylene is transformed into many products because of its C=C bond. These double carbon bonds allow alkenes to be highly reactive and are much more useful in the petrochemical industry.  There are many substances that react with alkenes by opening the double bond into two single bonds. These are called **addition reactions.**
• **Identify that ethylene serves as a monomer from which polymers are made.**	**Polymerisation** is when many identical small molecules (monomers) are combined together to form a larger molecule (polymer). Ethylene is a monomer from which polymers are produced (polyethylene). $CH_2{=}CH_2 \rightarrow (\text{-}CH_2\text{-}CH_2\text{-})_n$
• **Identify**	• Polyethylene is called an **addition polymer**.

polyethylene as an addition polymer and explain the meaning of this term.	• An **addition polymer** is when a polymer is produced by means of smaller molecules (monomers) opening out their double bond so as to join to the next monomer. They add together without any other product being produced.
• **Outline the steps in the production of polyethylene as an example of a commercially and industrially important polymer.**	There are two methods to produce polyethylene. One produces **low-density polyethylene** (LDPE), whilst the other produces **high-density polyethylene** (HDPE). **LDPE** • Production requires pressure of 1000-3000 atmospheres and temperature of about 300°C. • An organic peroxide is used as the initiator for the reaction. • The peroxide produces two free radicals which allow the monomer to join to others. **HDPE** • Also called **Ziegler-Natta** process. • Production takes place at only a few atmospheres of pressure and temperature of about 60°C. • Uses a catalyst which is a mixture of titanium(III) chloride and a trialkylaluminium compound such as triethylaluminium. • Process forms unbranched polyethylene molecules which are able to pack closely together. • Is crystalline in structure. • Started in 1955. **Steps:** 1. Initiation using organic peroxide 2. Chain-building cause two free radicals 3. Termination
• **Identify the following as commercially significant monomers:** o **Vinyl chloride** o **Styrene** **by both their systematic and common names.**	**Vinyl Chloride** Systematic Name: **Chloroethene** Common Polymer: **Polyvinylchloride** Structure:  **Styrene** Systematic Name: **Enthenylbenzene** Common Polymer: Polystyrene (**Polyethenylbenzene**) Structure:

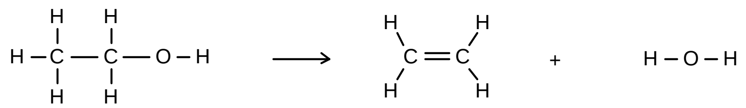


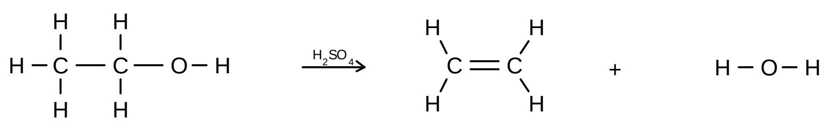
- **Describe the uses of the polymers made from the above monomers in terms of their properties.**

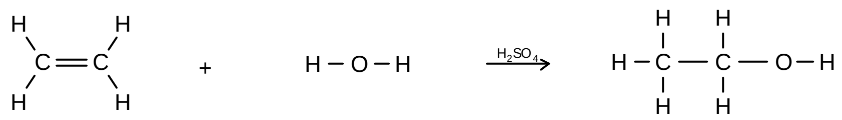
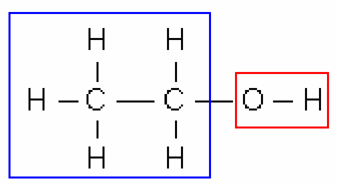
Monomer	Polymer	Properties	Uses
Ethylene	LDPE	• Low Density • Soft, flexible • Transparent, translucent. • Resists water & chemicals.	• Cling wrap. • Shopping bags • Food containers.
Ethylene	HDPE	• High density • Hard to semi-flexible. • Can take high temps. • Slow corrosion. • High MP	• Kitchen utensils • Toys • Building materials • Chairs • Car parts • Natural gas pipes
Vinyl Chloride	Polyvinyl chloride	• Made rigid and flame resistant with an additive • Water resistant • Electrical insulator	• Foam in furniture • Electrical insulation. • Appliance leads • Garden hoses • Floor tiles
Styrene	Poly-styrene	• Non-aerated (hard) • Aerated (soft) • Not chemically reactive • Does not become brittle • Low density • Heat and cold insulator	• Tool handles • CD cases • Packing foam • Foam cups

- **Gather and present information from first hand or secondary sources to write equations**

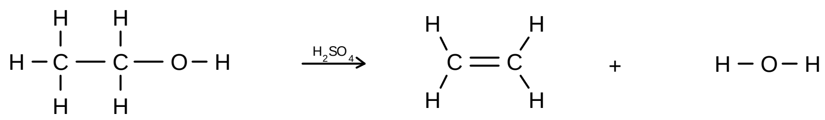
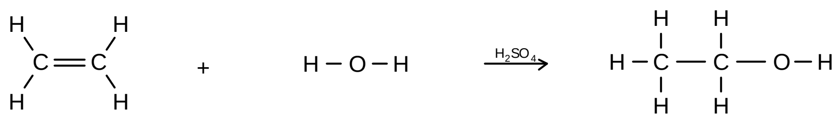
to represent all chemical reactions encountered in the HSC course.	
• **Identify data, plan & perform a first hand investigation to compare the relativities of appropriate alkenes with the corresponding alkanes in bromine water.**	**Experiment** Safety: Bromine water is toxic, poisonous and corrosive. Keep inside fume cupboard. Alkanes and alkenes are highly flammable and be used in well ventilated areas. Aim: To compare the relativities of alkenes with their corresponding alkanes. Method: 1. Add ten drops of an alkane substance to a test tube and ten drops of an alkene substance to a test tube. 2. Add a few drops of bromine water to each test tube. (Equal to both) 3. Record observations. Results: **Colour of Bromine water:** Brown/yellow **Colour of Bromine water + alkane:** No change **Colour of Bromine water + alkene:** Colourless $Br_{2}(aq) + H_{2}O(l) \rightleftharpoons HOBr(aq) + Br^{-}(aq) + H^{+}(aq)$ $C_{6}H_{12}(l) + HOBr(aq) \longrightarrow C_{6}H_{12}BrOH(aq)$ Analysis: • **A reaction has occurred if the solution goes colourless**. • Alkenes are more reactive than their corresponding alkanes on account of the C=C bond.
• **Analyse information from secondary sources such as computer simulations, molecular model kits or multimedia resources to model the polymerisation process.**	**Activity:** Modelling Polymerisation. Used ball & stick models, rearranged atoms and joined with others.
Focus 2 **Some scientists research the extraction of materials from biomass to reduce our dependence on fossil fuels.**	
• **Discuss the need for alternative**	**Reasons for Alternatives:** • Currently Australia has petroleum reserves that will last

sources of compounds presently obtained from the petrochemical industry.	for about ten years and natural gas reserves for about a hundred years. • Currently the petrochemical industry consumes 3-5% of oil. • Oil is non-renewable • Over 95% of fossil fuel is burnt as a source of energy. **Possible Solutions:** • Ethanol could be obtained from agricultural crops. • Ethanol can be produced by fermentation of starch and sugars. • Ethanol can produce ethylene through **dehydration**: 
• **Explain what is meant by a condensation polymer.**	A **condensation polymer** is a polymer that forms by the elimination of a small molecule (often water) when pairs of molecules join together.
• **Describe the reaction involved when a condensation polymer is formed.**	The process involves a reaction between **two functional groups** on two different monomers. A small molecule is eliminated and the two functional groups are linked together. **The process Requires:** • Two different monomers • Each monomer must have two functional groups. • A small molecular weight to be eliminated.
• **Describe the structure of cellulose and identify it as an example of a condensation polymer found as a major component of biomass.**	**Properties:** • Cellulose is a large component of the **biomass of plants**. • It is considered a condensation polymer of **glucose**. • It is found in all 'higher' plants. Cotton is 90% cellulose, wood is about 50% cellulose. **Structure:** • Cellulose forms linear polymers which contain much longer chains than starch. • Cellulose molecules form long chains which produce parallel arrays held together by **hydrogen bonding** between the main OH groups on the adjacent chains.
• **Identify that cellulose contains the basic carbon-chain structures needed to build petrochemicals and discuss its potential as a raw material.**	The bond linking monomer units in cellulose is an **ether** linkage. The **ether linkage** is the equivalent of the loss of water formed by the condensation between the 1-hydroxy group of one glucose unit and the 4-hydroxy group of another. **Cellulose's potential as a Raw Material:** • Cellulose contains glucose's carbon chain, meaning it could be used to derive a source for ethylene. • However, there is no simple way to break it down into glucose. • Enzymic breakdown is the first step in the production of petrochemicals.

	1. Cellulose (Broken down by enzymes) 2. Glucose (Broken down by yeast/distillation) 3. Ethanol (Broken down by catalysed dehydration) 4. Ethylene (Source for petrochemical industry)
• **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.**	**Name:** **PHB-PHV**: Poly-3-Hydroxybutyrate-poly-3-hydroxyvalerate **Enzyme or organism:** Bacterium, alcaligenes. **Properties:** • Not high impact. • Slow rate of degradation. • 90% polymer by weight. • Bimodal molecular weight **Uses:** • Plastics • Shampoo bottles. • Degradable materials in surgery • Replacing petrochemical plants with potato fields by getting potatoes to grow PHB-PHV instead of starch. • Biodegradable shampoo
<u>Focus 3</u> **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 is produced from ethanol by **dehydration**. **Dehydration** is the chemical reaction in which water is removed from a compound. Ethanol is dehydrated by heating it with concentrated **sulphuric acid** or phosphoric acid which acts as a **catalyst**. The **catalyst** lowers the activation energy for the reaction. $CH_3CH_2OH(g) \xrightarrow{H_2SO_4 \text{ catalyst}} C_2H_4(g) + H_2O(l)$ 
• **Describe the addition of water to ethylene resulting**	Industrial ethanol is generally produced by the **acid catalysed addition of water to ethylene**. • The reaction is carried out at 300°C.

in the production of ethanol and identify the need for a catalyst and the catalyst used.	• It uses either dilute sulphuric or phosphoric acid as the catalyst. • The reaction requires a **catalyst** as the water molecule itself will not attack the electrons in the **ethylene double bond**. $C_2H_4(g) + H_2O(l) \xrightarrow{\text{dilute } H_2SO_4} CH_3CH_2OH(g)$ 
• **Describe and account for the many uses of ethanol as a solvent for polar and non-polar substances.**	Ethanol is used as a **solvent** for dissolving substances that do not dissolve easily in water. • Ethanol has a water-loving (**hydrophilic**) OH group that allows it to dissolve **polar molecules** or **ionic substances**. • Ethanol also has a water-fearing (**hydrophobic**) hydrocarbon chain which can attract **non-polar molecules**.  **Uses:** • Most consumer products containing an alcohol are generally ethanol. • Ethanol is the least toxic of all the alcohols.
• **Outline the use of ethanol as a fuel and explain why it can be called a renewable resource.**	Ethanol is a commonly used fuel as it combusts readily with oxygen to produce **carbon dioxide, water and heat**. $C_2H_5OH(l) + 3O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(g) + \text{Heat}$ • Because ethanol contains an oxygen atom, the combustion is practically always complete. • There is hardly any formation of CO or C molecules, which only form during incomplete combustion. • The reaction is exothermic. **Renewable Resource:** Ethanol is regarded as a **renewable resource** as it can be made from plant materials and the products of its combustion are the reactants needed for photosynthesis.
• **Describe conditions under which fermentation of sugars is promoted.**	**Fermentation** is a process in which glucose is broken down to ethanol and carbon dioxide by the action of **enzymes** present in **yeast**. **Suitable Conditions:** • A micro-organism such as yeast

	• Water • A temperature of about blood temperature (**37°C**) • Air excluded, creating a low oxygen environment Once the ethanol concentration reaches 14-15% by volume, the yeast can no longer survive and the reaction is stopped.
• **Summarise the chemistry of the fermentation process.**	**The Process:** 1. Enzymes (**biological catalysts**) in the mixture convert any starch or sucrose in the mixture into **glucose**. 2. Other enzymes then convert the glucose into **ethanol** and **carbon dioxide**. $C_6H_{12}O_6(aq) \xrightarrow{\text{yeast}} 2C_2H_6O(aq) + 2CO_2(g) + \text{Heat}$ Glucose $\xrightarrow{\text{Yeast}}$ Ethanol + Carbon Dioxide + Heat
• **Define the molar heat of combustion of a compound and calculate the value for ethanol from first-hand data.**	The **molar heat of combustion** of a substance is the heat liberated when one mole of the substance undergoes complete combustion with oxygen at standard atmospheric pressure with the final products being carbon dioxide gas and liquid water. It is expressed in J mol^{-1} or kJ mol^{-1}. The formula for calculating the **molar heat of combustion** is: $\Delta H = -mC\Delta T$ Where: • ?H = Change in enthalpy (heat) (**J**). • m = Total mass of the substance heated in **grams**. • C = Specific heat capacity of the heated substance in **J K^{-1} g^{-1}**. • ?T = Change in temperature in **degrees Kelvin (K)**. The actual value for the **molar heat of combustion** for ethanol is 1360 kJ mol^{-1}.
• **Assess the potential of ethanol as an alternative fuel and discuss the advantages and disadvantages of its use.**	Currently, most energy is produced by the combustion of fossil fuels. However, they are **non-renewable** and are therefore running out. One possible solution is to use **ethanol** as a fuel. **Advantages:** • It is a **renewable resource**. • Ethanol undertakes **complete combustion** with minimal pollution. • Can be made by growing crops to ferment and distill. • Can be produced by **fermentation**. **Disadvantages:** • Only 10% content for current engines. • Disposal of waste products from **fermentation**. • Large areas of land will need to be devoted to growing ethanol sources.

	• Energy used for the growing and distilling needs to be renewable also. • Debate still exists over potential for engine damage.
• **Identify the IUPAC nomenclature for straight chained alkanols from C1 to C8.**	**Straight Chained Alkanols:** • C1 – Methanol • C2 – Ethanol • C3 – Propanol • C4 – Butanol • C5 – Pentanol • C6 – Hexanol • C7 – Heptanol • C8 – Octanol
• **Process information from secondary sources such as molecular model kits, digital technologies or computer simulations to model: the addition of water to ethylene & the dehydration of ethanol.**	**Dehydration of Ethanol:**  **Addition of water to Ethylene:**  These can both be represented using ball & stick or space filled models.
• **Process information from secondary sources to summarise the processes involved in the industrial production of ethanol from sugar cane.**	The process involves the sugar cane to be **fermented** to produce an ethanol **and water mixture**. This mixture is then distilled to obtain about a **96% pure** ethanol solution. *Sugar cane fermentation* Þ *Ethanol & Water Mixture* Ethanol & Water Mixture $\xrightarrow{\text{Distillation}}$ 96% Ethanol
• **Process information from secondary sources to summarise the use of ethanol as an alternative car fuel, evaluating the success of current usage.**	Ethanol has the potential to become the **primary fuel for cars**. This is due to a number of reasons. • Ethanol, unlike the hydrocarbons in petroleum, already contains oxygen, therefore enhancing the combustion in car engines and reducing the amount of hazardous exhaust emissions. • By using ethanol instead of petroleum, it will extend the life of petrol reserves. • Since the 1970's, Brazil has been using pure ethanol as the primary fuel for cars. Currently, over 13 million cars in Brazil are running on pure ethanol. However, there are a number of **problems**. • Many manufacturers in Australia claim that 10% ethanol fuel damages car engines. Despite many studies

	contradicting this, the Australian public at large are not convinced. • When the petroleum supplies do run out, much work will have to be done to engines to allow pure ethanol to be used.
• **Solve problems, plan & perform a first hand investigation to carry out the fermentation of glucose and monitor mass changes.**	Experiment Aim: To investigate & monitor mass changes during the fermentation of glucose. Method: **1.** Mixed solution of 1 teaspoon of sodium metabisulfite per one litre of water. **2.** Used solution to sterilise beaker, round flask and gas delivery tube. **3.** Added sucrose, salt and yeast to flask. **4.** Added water to flask. **5.** Placed stopper in flask. **6.** Recorded mass of flask and contents. **7.** Attached gas delivery tube from round flask to 250ml beaker filled with bromothymol blue. **8.** Placed in autoclave overnight. **9.** Re-recorded mass of flask and contents. **10.** Noted changes in colour of bromothymol blue. Results: Mass of Flask and Contents at start: 213.94 g Mass of Flask and Contents at end: 213.54 g Difference in mass: 0.40 g Conclusion: The fermentation was successful but if the flasks were filled too high, the contents could overflow during fermentation.
• **Present information from secondary sources by writing a balanced equation for the fermentation of glucose to ethanol.**	$C_6H_{12}O_6(aq) \xrightarrow{\text{Yeast}} 2CH_3CH_2OH(aq) + 2CO_2(g)$ + Heat Glucose $\xrightarrow{\text{Yeast}}$ Ethanol + Carbon Dioxide + Heat
• **Identify data sources, choose resources and perform a first-hand investigation to determine and compare heats of combustion of at least three liquid alkanols per gram and per mole.**	Experiment Aim: To find the molar heat of combustion and heat of combustion per gram of three alkanols. Theory: The **molar heat of combustion** of a substance is the heat liberated when one mole of the substance undergoes complete combustion with oxygen at standard atmospheric pressure. Equipment: • Ethanol spirit burner

- 1-Butanol spirit burner
- 1-Propanol spirit burner.
- Electronic balance
- Matches
- Insulated Aluminium can
- Water
- Thermometer

Method:

1. Record the mass of the ethanol spirit burner.
2. Fill can with 100mL of water.
3. Record temperature of water.
4. Light spirit burner and begin to heat the water.
5. When the temperature has been raised by approximately 10 degrees Celcius, extinguish the flame.
6. Re-record mass of ethanol spirit burner.
7. Record new water temperature.
8. Use **?H = -mC?t** to calculate enthalpy change.
9. Repeat for 1-Butanol & 1-Propanol.

Results:

Measurement / Calculation	Ethanol	1-Butanol	1-Propanol
Initial Water Temp (°C)	23	26	22.5
Final Water Temp (°C)	40	40	40
Initial Mass of spirit burner (g)	207.60	208.13	218.43
Final Mass of spirit burner (g)	206.61	207.28	217.34
Temp Rise (°K)	17	14	17.5
Mass of fuel burned (g)	0.99	0.85	1.09
Heat Energy produced (J)	13,140.2	12,807.1	15,502.2
Heat of combustion ($J\ g^{-1}$)	13,272.9	15,067.2	14,222.2
Molar heat of	611	1115	853

	Combustion (kJ mol^{-1}) | | | <u>Conclusion:</u> These figures are lower than the published values due to the loss of energy to the environment including the air, the can and insulation or through evaporation.
<u>Focus 4</u> Oxidation-reduction reactions are increasingly important as a source of energy.	
• **Explain the displacement of metals from solution in terms of transfer of electrons.**	A **displacement reaction** is a reaction in which a metal converts the ion of another metal to the neutral atom. **O** xidation **I** s **L** oss **R** eduction **I** s **G** ain
• **Identify the relationship between displacement of metal ions in solution by other metals to the relative activity of metals.**	A **more reactive metal** will **displace** a **less active metal** from a **solution of its ions**. This occurs because a more active metal atom loses one or more electrons, becoming a positive ion, whilst the less active metal will receive these electrons. **(Na, K) > (Li, Ca, Ba) > (Mg, Al, Fe, Zn) > (Sn, Pb) > (Cu) > (Ag, Au, Pt)**
• **Account for changes in the oxidation state of species in terms of their loss or gain of electrons.**	**Oxidation** is a loss of electrons. • When a metal undergoes oxidation, it has less electrons and therefore contains an abundance of positive charges. • The oxidation state of an atom is the overall charge. Therefore if an atom loses *n* number of electrons, its oxidation state becomes +n. An **increase** in oxidation state corresponds to a **loss of electrons**. A **decrease** in oxidation state corresponds to a **gain of electrons**. $Mg + 2H^{+} \longrightarrow Mg^{2+} + H_2$ $Mg \longrightarrow Mg^{2+} + 2e^{-}$ (Oxidation) $2e^{-} + 2H^{+} \longrightarrow H_2$ (Reduction)
• **Describe and explain galvanic**	**Reduction** is a gain of electrons. **Reduction-Oxidation** reactions are often called **redox**

<table>
<tr>
<td>cells in terms of oxidation/reduction reactions.</td>
<td>reactions.
The REDuction occurs at the CAThode.
The ANode undertakes OXidation.

• Redox reactions are used to generate electricity if the two reactions are physically separated.

• The electrons transferred in the reaction can be directed through an external circuit.

• Cells that produce an electric current are known as galvanic cells.</td>
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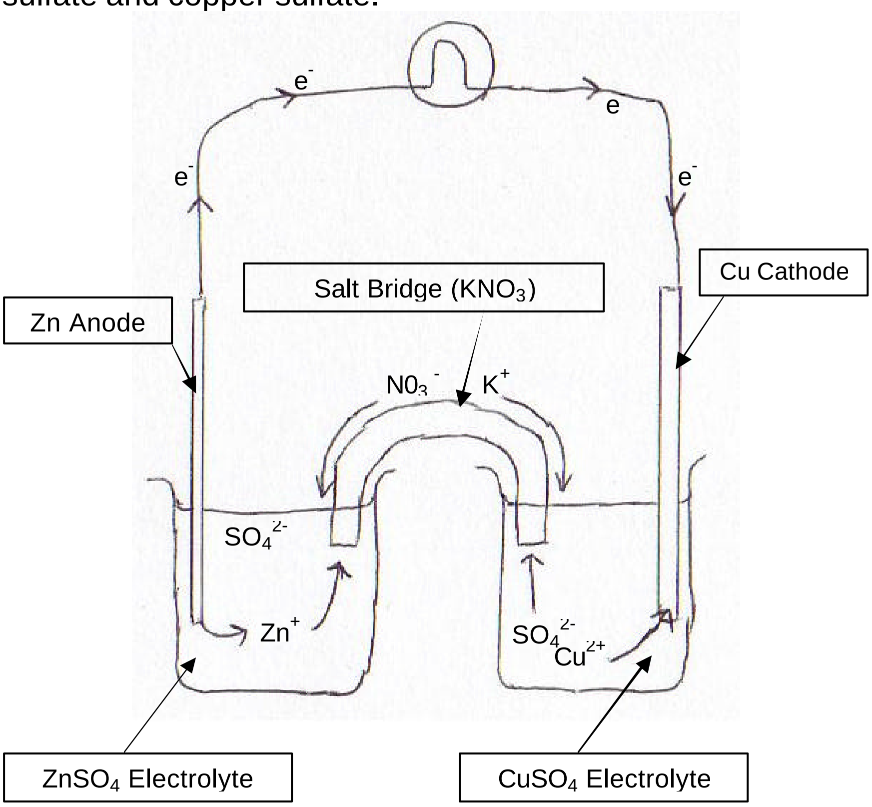
<tr>
<td>• Outline the construction of galvanic cells and trace the direction of electron flow.</td>
<td>Galvanic Cells Consist of:
• An oxidation ½ cell consisting of a metal electrode (anode) and an electrolyte solution containing the same metal ions.
• A reduction ½ cell consisting of a metal electrode (cathode) with a lower reactivity that the anode and an electrolyte solution containing the same metal ions.

This example contains a zinc anode, copper cathode and salt bridge of potassium nitrate. The electrolyte solutions are zinc sulfate and copper sulfate.


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<tr>
<td>• Define the terms anode, cathode, electrode and electrolyte to describe galvanic</td>
<td>• The anode is the negative electrode where the oxidation occurs.

• The cathode is the positive electrode where the reduction occurs. REDcat</td>
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</table>

cells.	• An **electrode** is a metal strip where either the oxidation or reduction occurs. Therefore both the anode and cathode are **electrodes**. • An **electrolyte** is a solution in which **ions** are dissolved, and can therefore carry an **electric current**.
• **Perform a first-hand investigation to identify the conditions under which a galvanic cell is produced.**	Experiment: Aim: To produce a galvanic cell. Method: **1.** Construct a ½ cell consisting of a strip of copper resting in a beaker half-filled with a solution of copper sulfate. **2.** Set up another ½ cell, this time using a zinc strip and zinc sulfate solution. **3.** Fold a piece of filter paper into a strip. Immerse it completely into a solution of potassium nitrate. This becomes the salt bridge. **4.** Place one end of salt bridge into the first ½ cell and the other end into the other ½ cell. **5.** Connect alligator clips to the metal strips and connect the other end of the wires to a voltmeter. Conclusion: For this practical to work, the two metals need to be of different standard potentials.
• **Perform a first-hand investigation and gather first-hand information to measure the difference in potential of different combinations of metals in an electrolyte.**	Experiment: Aim: To measure and compare the difference in potential of different combinations of metals in an electrolyte solution. Method: Use method as above but repeat the process using different combinations of metals, recording the reading on the voltmeter. Conclusion: The further apart the two metals were from each other on the metal reactivity series, the higher the voltage produced.
• **Gather and present information on the structure and chemistry of a dry cell or lead-acid cell and evaluate it in comparison to one of the following:** o **Button cell** o **Fuel cell** o **Vanadium redox cell** o **Lithium cell** o **Liquid junction**	**Comparison of Dry Cell & Lithium Cell:** **Dry Cell** The dry cell, zinc carbon cell, or Leclanché cell is a compact primary electrochemical cell which supplies electricity at small currents to electronic devices. **Structure:** Although cell design varies slightly from model to model, the most commonly used cell is comprised of a carbon rod of graphite which acts as the cathode. This carbon rod is immersed in a moist electrolyte of aqueous ammonium chloride (NH_4Cl). Also present is powdered manganese dioxide (MnO_2) and powdered carbon. This paste is located between the cathode and the anode.

photovoltaic device **In terms of chemistry, cost and practicality, impact on society and environmental impact.**	The anode is usually comprised of zinc and is present in the cell as the can casing. The cell also consists of an insulating washer or seal which ensures the circuit in the cell cannot be bypassed. The positive end of the cell generally sticks out the top and the negative terminal generally on the bottom. **Lithium Cell** A lithium cell is a galvanic cell that operates under the same principles as most galvanic cells but uses lithium as the anode. **Structure:** There are many types of lithium cells on the market but the most common type is the lithium-manganese dioxide cell which uses metallic lithium as the anode and manganese dioxide as the cathode. The electrolyte consists of a salt of lithium dissolved in an organic solvent. The design also caters for lithium's explosive nature and has a vent to allow any build-up of pressure to be vented, hence avoiding any explosion. The diagram also shows a silicone sealant used to keep the cell air and water tight. This is due to the fact that lithium is a highly reactive element that reacts with both air and water. As with the dry cell, the positive terminal generally sticks out the top of the cell and the negative terminal generally on the bottom. **Summary** Advantages of Dry Cell over Lithium Cell: • Costs less to produce than lithium cell. • Costs less for the consumer. • Doesn't react with air or water like the lithium cell does. • Is not as prone to explosion as the lithium cell is. • Much more common in electronic applications. Advantages of the Lithium cell over the dry cell: • Performs much better under high-current situations than the dry cell. • Lasts much longer than the dry cell before going 'flat.' • Lithium (3.04V) has higher standard potential than that of zinc (0.76V) used in the dry cell. • Lithium lasts longer and therefore fewer batteries are thrown onto landfill. • Can be used in smaller applications than the dry cell. • Can be used in more high-powered devices. • Much more reliable and can be used in life-saving applications like pacemakers. Overall, the lithium cell is the far superior cell over the dry cell in terms of its practicality, chemistry, societal impact and uses. It is therefore a more useful cell for modern electronic devices once the initial cost has been outlaid.

• **Solve problems and analyse information to calculate the potential E° requirement of named electrochemical processes using tables of standard potentials and half-equations.**	A standard electrode potential table contains values for molecules of substance with regards to their potential difference when undertaking oxidation or reduction. *Standard EMF of the complete reaction* = *Standard EMF of the reduction ½ reaction* + *Standard EMF of the oxidation ½ reaction*
<u>**Focus 5**</u> **Nuclear chemistry provides a range of materials.**	
• **Distinguish between stable and radioactive isotopes and describe conditions under which a nucleus is unstable.**	**Radioactivity** is the spontaneous disintegration of an unstable nucleus leading to the emission of radiation. **Isotopes** are atoms of the same element with differing numbers of neutrons in the nucleus. The key to knowing whether an isotope is stable or unstable is the **ratio of neutrons to protons**. For light elements, the stable ratio is approximately 1:1. As atomic number increases the number of neutrons to protons also increases. At z = 50, the stable ratio is approximately 1.3:1. At z = 80, the ratio is 1.5:1. An isotope is **unstable** if: • It has an atomic number from 1 to 83 and the ratio of neutrons to protons places it **outside the band of stability**. • It has an **atomic number greater than 83**. A unstable isotope produces three types of radiation: • **Alpha particles (Helium Nuclei)** – These have low penetrating, about 5cm of air. Symbol: α or ${}^{4}_{2}He$ • **Beta particles (Electron)** – These are much lighter, negatively charges particles with a moderate penetrating power, about 100cm of air. They exhibit the properties of electrons. Symbol: β or ${}^{0}_{-1}e$ • **Gamma rays (Electromagnetic radiation)** – These are not particles. They are pure radiation and carry no charge. They are extremely penetrating and can only be stopped by several centimetres of lead. Symbol: γ
• **Describe how transuranic elements are produced.**	**Transuranic elements** are artificial elements with an **atomic number greater than 92**. The reason this is possible is because when some elements are hit by a neutron, **instead of splitting they form a new element**. Elements that do not split are said to be not **fissile**.

	An example of a non **fissile** element is Uranium. $^{238}_{92}U + ^{1}_{0}n \longrightarrow ^{0}_{-1}e + ^{239}_{93}Np$
• **Describe how commercial radioisotopes are produced.**	The vast majority of **transuranic elements** are produced in either **nuclear reactors** or in **linear accelerators/cyclotrons**. **Nuclear Reactors:** **Radioisotopes** are prepared by neutron bombardment. Suitable target nuclei are placed in the reactor core and bombarded to produce the required isotope. **Linear Accelerators/Cyclotrons:** In a linear accelerator, positive particles are accelerated in a straight line along the axes of a series of cylinders. They are pushed from behind by a positive cylinder and pulled from in front by a negative cylinder. Cyclotrons also accelerate positive particles but they use a strong magnetic field to constrain the particles to a spiral path.
• **Identify instruments and processes that can be used to detect radiation.**	There are several ways radiation can be detected: • **Photographic film** will darken when it comes into contact with radiation. • A **cloud chamber** is an instrument which contains a supersaturated vapour of water or alcohol. When radiation passes through it, it ionises some of the air. The ions formed act as a nuclei upon which droplets of liquid form. • A **Geiger-Muller counter** allows ionised argon to have an electron knocked out from it. This electron is recorded as an electrical pulse. • A **scintillation counter** is an instrument that works on the fact that when certain substances are irradiated with radiation, a flash of light is emitted and counted in a **photomultiplier**.
• **Identify one use of a named radioisotope:** o **In industry** o **In medicine**	**Use in Industry:** Caesium-137 is used in **thickness gauges** in industry. **Use in Medicine:** Cobalt-60 is used in medicine as a **treatment for cancer**.
• **Describe the way in which the above named industrial and medical radioisotopes are used and explain their use in terms of their chemical properties.**	**Caesium-137** Caesium-137 is used in industry in **thickness gauges**. The radioactive source and a detector are arranged as shown in the diagram. By recording the amount of radiation which passes through the sheet of steel/paper/film/etc, the thickness of the sheet can be determined. **Cobalt-60** Cobalt-60 is used in medicine as a **treatment for cancer**. The **gamma emissions** from the radioactive source can be directed at cancerous growths to kill problematic cells.

	Unfortunately, some good cells are killed in the process.
• **Process information from secondary sources to describe recent discoveries of elements.**	The first **transuranic elements** were produced in nuclear reactors in the 1940's. • Element 106, **Seaborgium**, was made in 1974 by both American and Russian science teams. • Element 118, **Ununoctium,** and its immediate decay product, **Ununhexium**, were discovered at the Berkley lab's 88-inch cyclotron by bombarding targets of lead with an intense beam of high-energy **krypton ions**.
• **Use available evidence to analyse benefits and problems associated with the use of radioactive isotopes in identified industries and medicine.**	**Problems:** • **Radiation** is harmful to people and all other life forms. It can cause: o Tissue damage o Cancer o Genetic damage • **Alpha, beta & gamma** radiation can all cause normal cellular processes to be disrupted. • It is the **ionising** ability of **radiation** that makes it particularly dangerous. **Benefits:** Of course there are many benefits as mentioned above including **treatment of cancer** in medicine or the use in **thickness gauges** in industry.