Production of Materials

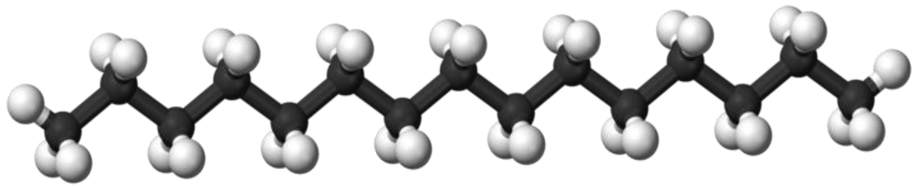
Fossil fuels provide both energy and raw materials such as ethylene for the production of substances

Identify the industrial source of ethylene:

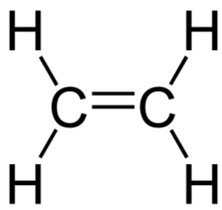
- Important petrochemical
- Otherwise known as "Ethene" C_2H_4
- Simplest of alkenes group
- Dispersion forces between molecules
- Can undergo combustion
- Low melting and boiling points and insoluble
- Non conductor of electricity
- Double C=C bond

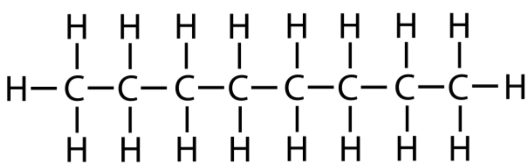
Fractions from Industrial cracking and refining of petroleum:

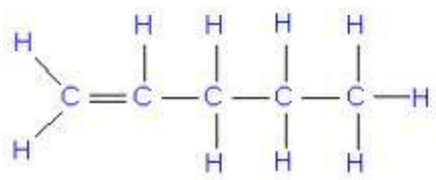
- Ethylene is obtained from the cracking of long chain petroleum fractions (pentadecane)



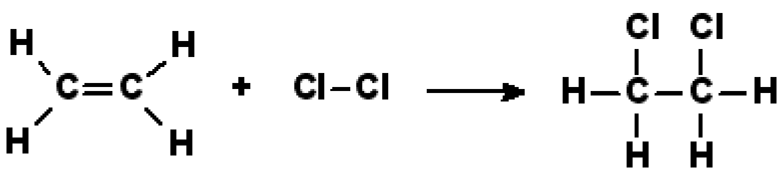
- Crude oil is fractionally distilled and low value (long polymers) are discovered
- The molecules are broken into smaller molecules by "thermal cracking" or a zeolytic catalyst
- Some form as alkenes because there are not enough H's
- Once the mixture as been cracked it is again fractionally distilled to collect valuable petrochemicals:







High reactivity of ethylene's double bond – Addition reactions:



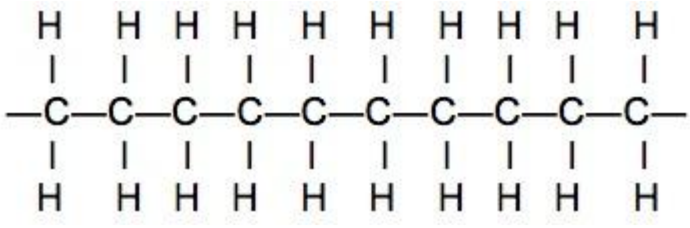
- Unstable double bonds break and in this case chlorine group is attached (chloroethane)
- Makes ethane with hydrogen, dibromoethane with bromine and ethanol with water
- Chemical versatility due to double C=C bond
- Highly reactive allowing many addition reactions to occur to manufacture useful products

Identify that Ethylene serves as a monomer from which polymers are made:

- Polymers are large long chain molecules made up of smaller molecules
- Widely used materials such as different plastics and synthetic fibres are manufactured polymers
- Ethylene is the feedstock in the manufacture of many polymers
- It's molecules can react with each other through addition reactions of the double bond to make polymers

Identify polyethylene as an addition polymer:

- Polyethylene is a polymer of ethylene
- It is made through an addition polymerisation of ethylene monomers
- It does not have double C=C bonds



Production of Low density polyethylene:

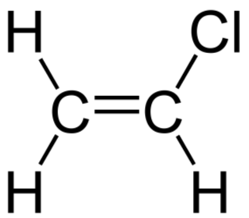
1. peroxide containing an O-O bond that breaks easily forming free radicals
2. used to initiate the joining of ethylene monomers
3. process must occur under high gas pressure to produce LDPE
4. production conditions result in molecules with the short branches that characterise LDPE

Production of high density polyethylene:

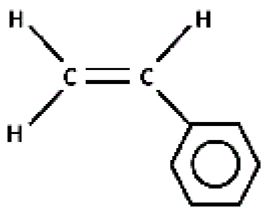
1. low gas pressures and a catalysts made of transition metals and organometallic compounds are used
2. enables more ordered orientation of ethylene to form the long unbranched and aligned molecules in HDPE.

Commercially significant monomers:

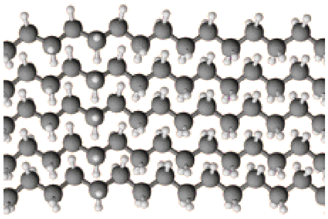
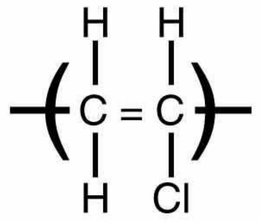
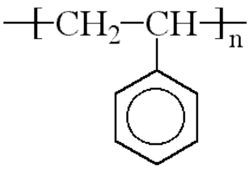
- a chlorine atom attached to an ethylene monomer is Chloroethene and more commonly known as vinyl chloride
- it is the monomer for P.V.C



- A benzene ring attached to an ethylene molecule is ethenylbenzene or commonly known as styrene
- It is the monomer for Polystyrene



Uses of Polymers:

Polymer	Monomer	Structure	properties	Uses
LDPE	Ethylene		• Low density • Flexible • Soft and clear	• Cling wrap • Book covers • Milk bottles • Soft toys
HDPE	Ethylene		• High density • Hard and strong	• Carry bags • Toys • Utensils • Rubbish bins • Rigid toys
PVC	Vinyl Chloride		• Rigid • Flame resistant • Water resistant •	• Drainage pipes and gutters • Flexible raincoats • Flower curtains • Electrical insulation • Garden hoses
Polystyrene	Styrene		• Transparent • Forms foam when gas added	• Car battery cases • CD cases • Tool handles • Packaging and insulation

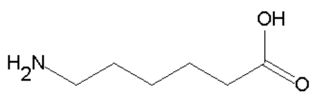
<u>Some scientists research the extraction of materials from biomass to reduce our dependence on fossil fuels</u>

Discuss the need for alternative compounds collected from petrochemical industries:

- Petroleum is a non-renewable fossil fuel
- Shortage will result in the loss of vital chemicals for manufacturing and petrol
- Ethylene is a critical petrochemical
- Products must be found to replace these
- They must be renewable and sustainable
- Living organisms must be used to replace petrochemicals to ensure renewability and sustainability

What is a condensation polymer?

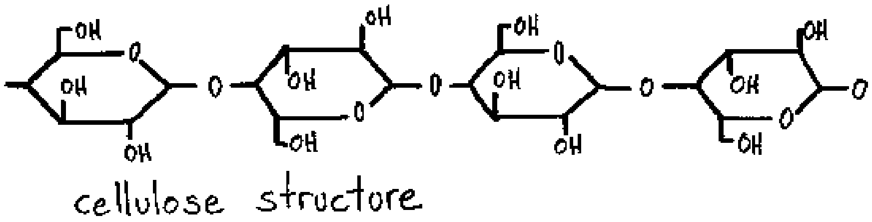
- It is a polymer formed when monomers join together by eliminating a water molecule
- All biological polymers are condensation polymers
- For example 6-aminohexanoic acid



- Two of these molecules can join together to make a polymer and water will be produced

The structure of Cellulose:

- The basic monomer for cellulose is glucose → large starch molecules → cellulose
- The glucose chains are joined together by hydrogen bonds
- The hydrogen bonding results in long strong cellulose fibres (why wood is so hard)
- The hydrogen bonding between the hydroxy groups make it insoluble and resistant to chemical attack
- Cellulose is a natural condensation polymer



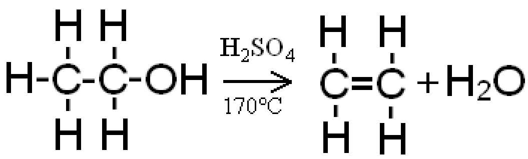
Cellulose contains carbon chain structures and future as raw material:

- A 3 carbon-chain and a 4 carbon-chain are present in the structure of a glucose monomer in a cellulose chain
- The carbon-chain sections could be changed to chemicals that, at present, are mostly made from petroleum
- No simple efficient way of economically breaking down cellulose has been developed
- Ethanol and ethylene can be used but will decrease food supplies

<u>Other resources such as ethanol are readily available from renewable resources such as plants</u>

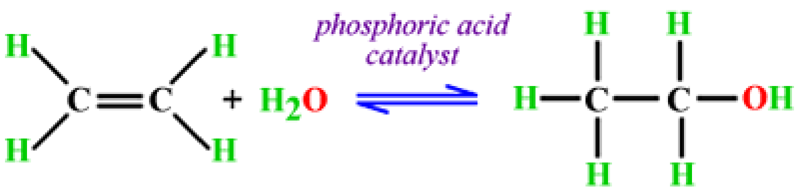
Dehydration of ethanol to ethylene:

- Dehydration is taking water molecules out of ethanol
- A catalyst is needed to make this reaction practical for industries
- The catalyst usually used is a high concentration of sulphuric acid
- $CH_3CH_2OH \longrightarrow CH_2{=}CH_2 + H_2O$



Hydration of ethylene to ethanol:

- Ethylene can be converted to ethanol through an addition reaction across the double bond
- A dilute concentration of Sulfuric acid is used as a catalyst for this reaction



Uses of ethanol as a solvent:

- Ethanol is able to solve polar and non-polar substances
- Hydrophobic Carbon chain can attract non-polar substances
- hydrogen bonding between the polar ends of the OH- molecule attached dissolve ionic and polar substances
- M.p and b.p are much more higher than their alkanes
- Smaller alkanols are completely soluble and larger ones become insoluble as the carbon chain gets longer
- Ethanol is able to solvate non-polar substances which don't dissolve in water
- Ethanol can be used in dissolving medicines, cleaning agents, food flavourings and colourings
- Ethanol is the least toxic of all the alkanols so it is used in consumer products

Ethanol as a fuel and a renewable resource:

- Ethanol combusts in air, releasing carbon dioxide, water and heat.
- Because the ethanol molecule contains an O atom it has complete combustion
- There is hardly any formation of the polluting CO or C forms, which form during incomplete combustion
- Ethanol is inflammable but it's energy content is not as high as in its alkanes

Conditions needed during fermentation:

- A suitable carbohydrate source (sugar from fruit, starch from wheat, corn, potatoes etc.)
- Live yeast
- Constant temp 25*C
- Anaerobic conditions (otherwise yeast will produce no alcohol but H20 and CO2)

Fermentation process:

- Feedstock preparation – molasses from sugar cane, corn or potatoes
- Fermentation – yeast microbes produce alcohols under anaerobic conditions
- Above 15% alcohol becomes toxic to microbes
- Distillation of alcohol – this removes water but a maximum of 92% alcohol is achievable
- For fuel it must be 99% pure which is achieved through a dehydrating chemical

What is the molar heat combustion of a compound:

- All combustion reactions are exothermic so ΔH_c is written as +tive (but is technically negative)
- "the molar heat of combustion is the heat given out when 1 mole of fuel is burned completely, with all reactants and products in their standard states at 25*C and 100kPa"
- Alkanols + oxygen → carbon dioxide + water
- $C_2H_5OH_{(g)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(g)}$ would be the standard formula of the combustion of ethanol
- fuels burn in a vapourised state so water is shown as a gas in this formula
- However the law states that substances must be in their standard states so water must be shown as a liquid
- $C_2H_5OH_{(l)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(l)}$ would be the correct formula

Calculate the combustion of ethanol:

1. Work out the heat capacity of ethanol based on data ($\Delta H = -mC\,\Delta T$)
2. Work out the heat produced per gram (ΔH per gram = ΔH /mass used)
3. Work out the molar heat of combustion ($\Delta H_c = \Delta H$ /g x MM of ethanol)

- Results obtained are often different to ones from scientists as the heat produced can escape into the air around the calorimeter. It can be improved through insulation etc.

Advantages and disadvantages of ethanol as a fuel:

Advantage	**disadvantage**
• Ethanol is a renewable fuel when it is made from the sugar of derived plants • The technology of fermenting and distillation is known and proven • The amount of carbon used and produced when ethanol combusts Is equal so it does not contribute to the greenhouse effect • Can be used at a 20% concentration in petrol without modification to car engines	• To completely replace petrol with ethanol 75% of the land's farming crops would have to be specifically made for ethanol • This would result in mass starvation and economic downturn • Current technology requires immense amounts of energy from fossil fuels which contribute to greenhouse effect • Pure ethanol is corrosive and will require changes in car engines which is too expensive

Assessment:

- 10% of petrol may conserve petrol supplies but does not reduce greenhouse gases
- Seems unlikely unless there if efficient production of glucose from cellulose from crop wastes to be used so crops do not have to be specifically grown for ethanol
- Renewable sources of energy (solar) can be used to power processes used to develop ethanol

IUPAC nomenclature of alkanols:

1. Methanol
2. Ethanol
3. Propenol
4. 2-Butanol (why?) $CH_3CH_2CHOHCH_3$ The "OH" group Is not on the end and on the 2nd carbon so similarly
5. Pentanol
6. Hexanol
7. Heptanol
8. Octanol

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

Explain Displacement reactions:

- Displacement reactions occur when the higher metal displaces another
- This is due to oxidation-reduction reactions and the transfer of electrons
- The more active metal forms a deposition and the other metal is dissolved

Relationship between the displacement of metals and reactivity:

- The metal atom forms an ion and the metal ion forms an atom
- The metal with higher activity usually forms atoms from ions
- The other metal forms ions from atoms
- This happens when the metal with the lower activity releases its electrons which is accepted by the metal with the higher activity.

Changes in oxidation state of species:

- Oxidation numbers are assigned based on the ionic charge o the element e.g. Fe^{2+} = oxidation number of 2
- When an oxidation number increases, the element has oxidised (lost electrons and forms ions)
- When the number decreases, it has reduced (gained electrons and formed atoms)

Everything on Galvanic cells:

- Hehehehe, you SHOULD be pro at this by now adrita, you don't need the next few dot points, just look at your assignment.
- Cu + Zn ;) But just to help you because you suck so much look at KISS ilz

<u>Nuclear chemistry provides a range of materials</u>

Stable and unstable radioisotopes and conditions under which a nucleus is unstable:

- First of all the mass number is P+N and therefore will always be a whole number
- The atomic mass is when it is P+N+e so it is not always a whole number
- Anyway so, atoms have equal ratios of P:N and isotopes do not have equal ratios of P:N
- Hence the charges in the nucleus are imbalanced and the particles start to repel each other
- This makes them an unstable radioisotope (same element with variation of neutrons)
- Isotopes are usually named after their mass number E.g. Chlorine-37

How is stability achieved?

- Stability is achieved when the neutron undergoes radioactive decay to get rid of some energy
- Radioactive decay is also known as a half-life, which may take a few seconds, hours, days or millions of years
- 1 neutron decays forms 1 proton and 1 electron

Name	**Formula**	**How it reacts**	**Penetrative power**
Alpha particle (helium nucleus)	${}^{4}_{2}He$	-4 in mass no. -2 in atomic no. ${}^{222}_{88}Ra \longrightarrow {}^{4}_{2}He + {}^{218}_{86}Rn$	Low – paper
Beta particle (electron)	${}^{0}_{-1}e$	Mass no. stays the same + 1 in atomic number ${}^{14}_{6}C \longrightarrow {}^{14}_{7}N + {}^{0}_{-1}\beta$	Moderate – lead sheet
Gamma (electromagnetic radiation)	0	Does not react	High – 5cm lead sheet or concrete

Why are transuranic elements produced?

- It has been discovered that once an element has over 80 protons and about 120 neutrons it is too large to be stable
- Naturally occurring elements with large nuclei are very unstable and radioactive
- Largest naturally occurring isotopes are of uranium
- However larger elements with larger nuclei can be artificially produced called 'transuranic elements'
- These can be used for special purposes in industry and medicine

How transuranic elements are produced:

- Can be produced by neutron bombardment of elements

Where	How/example
In a nuclear reactor	• an element is placed in a nuclear reactor and bombarded with neutrons • a neutron will eventually strike the nucleus and cause the element to gain a neutron • it will then undergo decay e.g. Transuranic uranium-238 $^{238}_{92}\mathrm{U} + \mathrm{n} \rightarrow {}^{239}_{92}\mathrm{U} \rightarrow {}^{239}_{93}\mathrm{Np} + \mathrm{e}^-$
In a particle accelerator	• beyond the element 95 it is only possible to make small numbers of new atoms in a particle accelerator • atomic nuclei are accelerated up to very high speeds using magnetic fields • often 2 nuclei collide to form a new nucleus E.g. a lead and a calcium nucleus $^{206}_{82}\mathrm{Pb} + {}^{48}_{20}\mathrm{Ca} \longrightarrow {}^{254}_{102}\mathrm{No}$ Lead nucleus + Calcium nucleus → Nobelium nucleus

Production of commercial radioisotopes:

- commercial radioisotopes are produced by neutron bombardment
- usually in a nuclear reactor
- similar way to how transuranic elements are produced
- one of the most important commercial isotopes is Cobalt-60
- It is unstable and undergoes beta decay while emitting gamma radiation
- By enclosing cobalt-60 in a shielded container with a narrow opening can produce a thin beam of gamma rays which is very useful in industry and medicine

Instruments and processes that detect radiation:

Instrument/process	What it detects	How it detects
Photographic film	Radiation	Radioactive areas on the film become white
Geiger counter	Detects radiation because of the ionisation it causes	A tube of non conductive gas (noble usually argon) is exposed to radiation (alpha particles which can ionise thousands of atoms) to see If it becomes conductive which is measured by an electrical circuit.
Scintillation counter	Detects radiation by flashes of light emitted from certain chemicals	Certain chemicals emit light when exposed to radiation, each beam of light is counted by an electronic circuit and recorded

Uses of Cobalt-60 in industry:

- Sterilising medical supplies
- Bandages etc. are exposed to gamma rays which destroy any bacteria or fungi present
- In aircraft manufacture gamma rays are passed through aircraft parts to produce an x-ray like image of a welded joint
- The image let engineers determine the quality of the welded joint instead of having to take the whole aircraft apart
- Cobalt-60 has a half-life of 5.3 years meaning it has a useful life of 6-10 years before getting replaced
- It is convenient and economically worthwhile for use in medicine and industry
- Most of the world's supply is made in Canada

Uses of Technitium-99 in medicine:

- Used in over half of current medical procedures such as pinpointing brain tumours
- Can be changed to a number of oxidation states giving flexibility to target a certain organ
- It is attached to a biological molecule concentrated in the organ that is being investigated
- Used as it has a very short half-life of 6 years
- Emits low gamma radiation, does not damage surrounding tissues but allows a certain area to be investigated
- Quickly able to be eliminated from the body
- Can be reacted to form a compound to biologically bind to a concentrate in the organ of interest