

Combined Science

Revision information for Mock 2.

You will sit a Paper 2 in Biology, Chemistry and Physics, each paper is 1hr 15mins covering the following topics.

Biology

Homeostasis and response

Inheritance, variation and evolution

Ecology

Chemistry

The rate and extent of chemical change

Organic chemistry

Chemical analysis

Chemistry of the atmosphere

Using resources

Physics

Forces

Waves

Magnetism and electromagnetism

Chemistry Fact Sheet – Paper 2 – combined science higher tier

Italics – Higher Only

Rate & Extent of Chemical Reactions	Rates of reaction	<p>1. The rate of a chemical reaction can be found by measuring the quantity of a reactant used or the quantity of product formed over time.</p> <ul style="list-style-type: none"> • Mean rate of reaction = $\frac{\text{quantity of reactant used}}{\text{Time taken}}$ • Mean rate of reaction = $\frac{\text{quantity of product formed}}{\text{Time taken}}$ <p>2. The quantity of reactant or product can be measured by the mass (grams) or by volume (cm³)</p> <p>3. The units of rate of reaction are g/s or cm³/s.</p> <p>4. <i>The quantity of reactions can also be given in terms of moles and the units for rate of reaction in mol/s.</i></p> <p>5. Factors which affect the rate of chemical reactions include –</p> <ul style="list-style-type: none"> • Concentration of reactant • Pressure of reacting gases • Surface area of solid reactants • Temperature • Presence of a catalyst.
	Collision theory & activation energy	<p>6. Collision theory states that chemical reactions can only occur when particles collide with each other with enough energy.</p> <p>7. The minimum amount of energy that particles must have to react is called the activation energy.</p> <p>8. Increasing the concentration of reactants in solution, the pressure of reacting gases and the surface area of solid reactants increases the frequency of collisions and so increases the rate of reaction.</p> <p>9. Increasing the temperature increases the frequency of collisions and makes the collisions more energetic and so increases the rate of reaction.</p>
	Catalysts	<p>10. Catalysts change the rate of chemical reactions but are not changed or used up during the reaction.</p> <p>11. Different reactions need different catalysts.</p> <p>12. Enzymes are catalysts in biological systems.</p> <p>13. Catalysts increase the rate of reaction by providing a different pathway for the reaction that has a lower activation energy.</p>
	Reversible reactions	<p>14. In some chemical reactions, the products of the reaction can react to produce the original reactants. These reactions are called reversible reactions.</p> $A + B \rightleftharpoons C + D$ <p>15. The direction of the reversible reactions can be changed by changing the conditions, for example heating or cooling the reaction.</p> $\text{Ammonium chloride} \xrightleftharpoons[\text{heat}]{\text{cool}} \text{ammonia} + \text{hydrogen chloride}$

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	Energy Changes reversible reactions	<p>16. If a reversible reaction is exothermic in one direction, it is endothermic in the opposite direction.</p> <p>17. The same amount of energy is transferred in each direction.</p> <p>18. For example –</p> $\begin{array}{ccccccc} & & \text{exothermic} & & & & \\ \text{Hydrated copper sulfate} & \rightleftharpoons & \text{anhydrous copper sulfate} & + & \text{water} & & \\ \text{(blue)} & & \text{endothermic} & & \text{(white)} & & \end{array}$
	Equilibrium	<p>19. When a reversible reaction, equilibrium is reached when the forward and reverse reactions occur at exactly the same rate.</p> <p>20. Equilibrium can only be achieved in a closed system where no materials can escape. This is a sealed container for gases but a beaker for liquids is good enough.</p>
	<i>Effect of Changing conditions on equilibrium (Higher Tier Only)</i>	<p>21. <i>If a system is at equilibrium and a change is made to any of the conditions, then the system responds to counteract the change.</i></p> <p>22. <i>The effects of changing conditions on a system at equilibrium can be predicted using Le Chatelier's Principal.</i></p> <p>23. <i>If the concentration of one of the reactants or products is changed, the system is no longer at equilibrium and the concentrations of all the substances will change until equilibrium is reached again.</i></p> <p>24. <i>If the concentration of one of the reactants is increased, more products will be formed until equilibrium is reached again.</i></p> <p>25. <i>If the concentration of a product is decreased, more reactants will react until equilibrium is reached again.</i></p> <p>26. <i>If the temperature of a system at equilibrium is increased, the endothermic reaction is favoured in an attempt to cool the system.</i></p> <p>27. <i>If the temperature of a system at equilibrium is decreased, the exothermic reaction is favoured in an attempt to heat the system.</i></p> <p>28. <i>For gaseous reactions at equilibrium –</i></p> <ul style="list-style-type: none"> • <i>An increase in pressure causes the equilibrium position to shift towards the side with the smaller number of molecules as shown by the symbol equations for that reaction.</i> • <i>A decrease in pressure causes the equilibrium position to shift towards the side with the larger number of molecules as shown by the symbol equations for that reaction.</i>
Carbon compounds as fuels.	Crude oil, hydrocarbons and alkanes	<p>29. Crude oil is the remains of ancient biomass consisting mainly of plankton that was once buried in mud; it is a finite resource found in rocks.</p> <p>30. Crude oil is a mixture of hydrocarbon compounds.</p> <p>31. Hydrocarbon compounds are molecules made only of carbon and hydrogen atoms.</p> <p>32. Most of the hydrocarbons in crude oil are alkanes.</p> <p>33. Alkanes are a homologous series with the formula C_nH_{2n+2}</p> <p>34. Alkane molecules are saturated; they have single bonds between the carbon atoms.</p> <p>35. The first 4 members of the alkane series are methane, ethane, propane and butane.</p> <p>36. The combustion of hydrocarbons releases energy and produces carbon dioxide and water as the carbon and hydrogen atoms in the molecules are oxidised.</p> <p>37. As hydrocarbon molecules get larger, they become more viscous, less flammable and have higher boiling points.</p>

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Carbon compounds as fuels and feedstock	Fractional distillation	<p>38. Fractional distillation is the method used to separate the molecules in crude oil into fractions, each of which contains molecules with a similar number of carbon atoms.</p> <p>39. Many fuels such as petrol, diesel oil, kerosene, heavy fuel oil and liquefied petroleum gases (LPG) are produced from crude oil.</p> <p>40. Many useful materials are produced using the fractions from crude oil by the petrochemical industry such as solvents, lubricants, polymers and detergents.</p> <p>41. During fractional distillation the molecules in crude oil are heated to evaporate them.</p> <p>42. Smaller hydrocarbons have lower boiling points and rise higher in the fractional distillation column before condensing.</p> <p>43. Larger molecules have higher boiling points and condense lower down the column where the temperature is hotter.</p>
	Cracking and the alkenes.	<p>44. Fractions containing larger hydrocarbon molecules are in less demand than those containing smaller hydrocarbon molecules.</p> <p>45. Large hydrocarbon molecules can be broken down (cracked) using steam or catalytic cracking.</p> <p>46. The conditions for steam cracking are mix vapour with steam and heat to very high temperature.</p> <p>47. The conditions for catalytic cracking are to heat to 500°C and pass over hot catalyst.</p> <p>48. The products of cracking are smaller hydrocarbons and another types of hydrocarbon called alkenes.</p> <p>49. Alkenes are hydrocarbons that contain a carbon – carbon double bond.</p> <p>50. When bromine water reacts with an alkene it turns from orange/ brown to colourless.</p> <p>51. Bromine water remains orange / brown when added to an alkane.</p> <p>52. Alkenes are used to produce polymers.</p> <p>53. The general formula for the homologous series of alkenes is C_nH_{2n}</p> <p>54. Alkene molecules are unsaturated.</p> <p>55. The first 4 alkenes in the series are called ethene, propene, butene and pentene.</p> <p>56. The functional group in an alkene is C=C</p> <p>57. Alkenes react with halogens; the halogen attaches to both carbons that formed the double bond.</p> <p>58. Bromine water can be used to test for an alkene; the bromine water will change from orange / brown to colourless when added to an alkene.</p>

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Chemical analysis	Purity, formulations and chromatography	<p>59. A pure substance is a single element or compound not mixed with any other substance.</p> <p>60. Pure substances have specific melting and boiling points that helps us identify them.</p> <p>61. A formulation is a mixture that has been designed as a useful product, eg paints, medicines and foods.</p> <p>62. Chromatography can be used to separate substances using a stationary and a mobile phase.</p> <p>63. R_f value = $\frac{\text{distance moved by the substance}}{\text{distance moved by the solvent}}$</p> <p>64. Different compounds have different R_f values in different solvents which can be used to help identify the compounds.</p> <p>65. The compounds in a mixture will be separated into different spots depending on the solvent.</p> <p>66. A pure compound will only produce a single spot.</p> <p>67. In paper chromatography, the starting line should be drawn in pencil as it is insoluble and will not be dissolved by the solvent and interfere with the results.</p>
Chemical analysis	Identifying gases.	<p>68. The test for hydrogen uses a burning splint held over the end of the tube of gas. The result is a pop sound.</p> <p>69. The test for oxygen uses a glowing splint inserted into the gas. The splint relights in oxygen.</p> <p>70. The test for carbon dioxide uses limewater (calcium hydroxide solution). Carbon dioxide makes limewater turn cloudy when bubbles through it.</p> <p>71. The test for chlorine uses damp litmus paper. The paper bleaches and turns white.</p>
Chemistry of the atmosphere	Gases in the atmosphere	<p>72. For 200 million years the percentages of the gases in the atmosphere have been much as the same as today.</p> <p>73. About 4/5ths of today's atmosphere is (80%) is nitrogen (N_2)</p> <p>74. About 1/5th is oxygen (O_2)</p> <p>75. There are small proportions of other gases including carbon dioxide, water vapour and noble gases (group 0)</p>
	The early atmosphere of the Earth	<p>76. Evidence for the Earth's early atmosphere is limited because of the time scale of 4.6 billion years.</p> <p>77. One theory suggests volcanic activity released carbon dioxide, water vapour and other gases that formed the first atmosphere.</p> <p>78. The water vapour condensed to form oceans.</p> <p>79. Carbon dioxide dissolved in the water and carbonates were precipitated forming sediments, reducing the amount of carbon dioxide in the atmosphere.</p> <p>80. Algae began photosynthesising about 2.7 billion years ago, which created oxygen in the atmosphere.</p> <p>81. Plants then evolved over the next billion years and the percentage of oxygen increased.</p> <p>82. Photosynthesis by algae and plants also decreased the percentage of carbon dioxide in the atmosphere.</p> <p>83. Carbon dioxide was also decreased by the formation of sedimentary rocks and fossil fuels that contain carbon.</p>

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Greenhouse gases	Greenhouse gases	<p>84. Greenhouse gases in the atmosphere maintain temperatures on Earth high enough to support life.</p> <p>85. Water vapour, carbon dioxide and methane are greenhouse gases.</p> <p>86. Greenhouse gases let short wave radiation from the sun through to Earth.</p> <p>87. Greenhouse gases absorb the infra-red radiation emitted by the Earth, trapping the energy.</p> <p>88. The burning of fossil fuels to make electricity, heat homes and run cars (human activities) has increased the amount of carbon dioxide in the atmosphere.</p> <p>89. Swamps and rice fields produce methane as does the growing number of grazing cattle and their decomposing waste.</p> <p>90. Based on peer-reviewed evidence, many scientists believe that human activities will cause the temperature of the Earth's surface to increase and will result in global climate change.</p> <p>91. It is difficult to model such complex systems so we cannot predict with certainty the effects of increased levels of greenhouse gases.</p>
	Global climate change	<p>92. Global warming is a major cause of climate change.</p> <p>93. Consequences of global climate change include;</p> <ul style="list-style-type: none"> - rising sea levels as a result of melting ice caps - an increased number of extreme weather events, - changes in temperature and rainfall which could impact on food production, - changes to the distribution of wildlife species with some becoming extinct.
Carbon footprint	Carbon footprint	<p>94. The carbon footprint is the total amount of carbon dioxide and other greenhouse gases emitted over the full life cycle of a product, service or event.</p> <p>95. The carbon footprint could be reduced by reducing emissions of carbon dioxide and methane.</p> <p>96. Carbon dioxide emissions could be reduced by carbon capture; pumping the carbon dioxide produced underground into porous rocks.</p> <p>97. Plant based diets would reduce demand for beef and reduce methane emissions.</p> <p>98. Biofuels use carbon dioxide when they grow but create carbon dioxide when they are burnt so are classed as carbon neutral.</p> <p>99. Reducing emissions will have cost implications in all manufacturing and transport industries.</p>

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Atmospheric pollutants	Atmospheric pollutants from fuels	<p>100. Most fuels, including coal, contains carbon and /or hydrogen and may also contain some sulfur.</p> <p>101. Carbon dioxide, sulfur dioxide, carbon monoxide, water vapour and oxides of nitrogen are all produced by the burning of various fuels.</p> <p>102. The complete combustion of a hydrocarbon fuel produces carbon dioxide and water vapour.</p> <p>103. The incomplete combustion of a hydrocarbon fuel produces carbon monoxide and water vapour (when less oxygen is available).</p> <p>104. Particulates of carbon (soot) can also be produced during incomplete combustion. These cause global dimming and health problems.</p> <p>105. Carbon monoxide is poisonous (toxic).</p> <p>106. Carbon monoxide is colourless and odourless so is not easily detected.</p> <p>107. Sulfur impurities in fuels form sulfur dioxide when burnt.</p> <p>108. At high temperatures (eg in engines) nitrogen from the atmosphere reacts with oxygen to form oxides of nitrogen.</p> <p>109. Sulfur dioxide and oxides of nitrogen cause acid rain and breathing problems.</p>
Using the Earth's resources	Earth's resources	<p>110. Finite natural resources from the Earth. Oceans and atmosphere are processed to provide energy and materials.</p> <p>111. Some of these finite resources will run put if we continue to exploit them e.g. fossil fuels.</p> <p>112. Renewable resources can be replaced as we use them e.g. crops for biofuels.</p> <p>113. Chemistry helps improve agriculture and industrial processes to provide new products and in sustainable development.</p>
	Potable water	<p>114. Water that is safe to drink is called potable water.</p> <p>115. Potable water is not pure as it may contain dissolved substances.</p> <p>116. In the UK rain water provides ground water which is settled then filtered and sterilised to produce potable water.</p> <p>117. Sterilising agents include chlorine, ozone or UV light. These kill microbes.</p> <p>118. If supplies of fresh water are limited salty water (sea water) is desalinated.</p> <p>119. Desalination can be done by distillation or reverse osmosis. Both use large amounts of energy.</p> <p>120. Pure water has a pH of 7 and a boiling point of 100°C</p>
	Waste water	<p>121. Waste water from homes and industry needs treating before being released into the environment.</p> <p>122. Sewage and agricultural waste needs organic matter and harmful microbes removing.</p> <p>123. Sewage treatment includes: screening to remove large solids and grit sedimentation to produce sewage sludge and effluent the sewage sludge is broken down by anaerobic digestion and dried aerobic biological treatment of effluent which is returned into the environment.</p>

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	<i>Alternative methods of extracting metals</i>	<p>124. <i>Copper ores (and other metal ores) are becoming scarce.</i></p> <p>125. <i>Phytomining and bioleaching are used to extract copper from low grade ore.</i></p> <p>126. <i>Phytomining uses plants to absorb metal compounds. The plants are then burnt to produce ash and the metals extracted from the ash.</i></p> <p>127. <i>Bioleaching uses bacteria to produce leachate solutions that contain metal compounds.</i></p> <p>128. <i>The copper can be obtained from the solutions by displacement using scrap iron or by electrolysis.</i></p>
<i>Life cycle assessments and recycling</i>	<i>Life cycle assessment.</i>	<p>129. Life cycle assessments (LCAs) are carried out to assess the environmental impact of a product.</p> <p>130. LCAs assess the following stages:</p> <ul style="list-style-type: none"> - extracting and processing raw materials - manufacturing and packaging - use and operation during its lifetime - disposal at the end of its useful lifetime, including transport at each stage <p>131. Use of water, materials, energy and the production of some waste can be measured and quantified.</p> <p>132. It is difficult to quantify other things eg pollutants released into the atmosphere so value judgements have to be used.</p> <p>133. LCAs are not purely objective. Some values are subjective.</p> <p>134. LCAs could be biased and be misused for advertising.</p>
	<i>Reducing use of resources</i>	<p>135. There are 2 ways we can reduce the use of resources: reduce how much we use, reuse items and recycle materials.</p> <p>136. Reducing the use of resources also saves energy, waste and cuts down environmental impacts.</p> <p>137. Metals, glass, building materials, clay ceramics and most plastics are produced from limited resources.</p>