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| **C3a** | **Rates of Reaction (1)** |  | **C3a** | **Rates of Reaction (1)** |
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| 1 | Name a slow reaction. |  | 1 | Rusting is a slow reaction |
| 2 | Name a fast reaction. |  | 2 | burning and explosions are fast reactions |
| 3 | What does the rate of a reaction measure? |  | 3 | It measures how much product is formed in a fixed time period. |
| 4 | What are the common units for the rate of reaction? |  | 4 | g/s (grams per *second*) or g/min*ute*  cm3/s (cm3 per *second*) or cm3/min*ute* |
| 5 | Label the apparatus needed to measure the rate of reaction making a gas: |  | 5 | Gas syringe  Flask  http://www.btinternet.com/~chemistry.diagrams/gas-syringe.gif |
| 6 | What would a mass loss graph for the reaction of magnesium and hydrochloric acid look like? |  | 6 |  |
| 7 | What would a gas volume graph for the reaction of magnesium and hydrochloric acid look like? |  | 7 | http://www.antonine-education.com/jirvine/Chemistry_GCSE/C2b/Rate_1.JPG |
| 8 | What do the graphs in Questions 6 and 7 tell you about the rate during the reaction of magnesium and hydrochloric acid? |  | 8 | The reactions are fastest at the start and they then slow down until they stop, this happens when the lines go flat. |
| 9 | How could you find the rate of reaction and units from the graphs in Q6,7? |  | 9 | Work out the gradient of the lines. The faster the reaction, the steeper the line |
| 10 | What would an experimental results graph for a series of reactions of magnesium and different concentrations of hydrochloric acid look like?  (You time how long a 2cm piece of magnesium takes to dissolve in different concentrations of hydrochloric acid) |  | 10 |  |
| 11 | How would you tell which of the reactions in Q10 is the fastest? |  | 11 | The fastest reaction has the shortest reaction time. |
| **12** | **How could you find the reaction times for higher concentrations of acid using the Q10 graph** |  | **12** | **Extrapolation.**  **Extend the line to higher concentrations** |
| **13** | **How could you find the reaction times for lower concentrations of acid using the Q10 graph** |  | **13** | **interpolation.**  **Extend the line to lower concentrations** |
| 14 | Explain why a reaction stops. |  | 14 | A reaction stops when the limiting reactant has been used up. |
| 15 | What is the limiting reactant? |  | 15 | It is the reactant not in excess, the reactant in the lowest amount that is all used up at the end of the reaction. |
| 16 | What is the amount of product formed proportional too? |  | 16 | It is directly proportional to the amount of limiting reactant used. |
| **17** | **Explain why question 16 happens** |  | **17** | **There are only so many particles of the limiting reactant present. Once these have reacted there will be no more product formed, so the number of product particles is directly proportional to the number of reactant particles.** |
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| **C3b** | Rate of reaction (2) |  | **C3b** | Rate of reaction (2) |
| 1 | What has to happen before a chemical reaction happens? |  | 1 | A chemical reaction takes place when particles collide **successfully**. |
| 2 | What does the rate of reaction depend on? |  | 2 | The rate depends on the number of collisions between reacting particles. |
| **3** | **Explain why the rate of reaction depends on the collisions of the reactants.** |  | **3** | **The collision frequency of reacting particles determines the rate, if the collisions get more frequent, the reaction speeds up.** |
| **4** | **Explain why the rate of reaction depends on the energy of the collisions.** |  | **4** | **The energy transferred during the collision depends on whether the collision is successful or effective. Only particles that have more than the Activation Energy for the reaction will collide successfully and react.** |
| 5 | Describe the effect of changing temperature on the rate of a chemical reaction. |  | 5 | Increasing the temperature, increases the rate. |
| 6 | Explain, in terms of the reacting particle model, why changes in temperature change the rate of reaction. |  | 6 | When the reactant particles warm up, they move faster. They collide more often with the other particles, so the rate increases. |
| **7** | **Explain, using the reacting particle model, why changes in temperature change the rate of reaction.** |  | **7** | **Not all collisions are successful or effective, only those with more than the activation energy will be successful. Heating particles gives them more kinetic energy so a greater number have enough energy to react.** |
| 8 | Describe the effect of changing the concentration on the rate of a chemical reaction. |  | 8 | Increasing the concentration, increases the rate. |
| 9 | Explain, in terms of the reacting particle model, why changes in concentration change the rate of reaction. |  | 9 | Increasing the concentration means putting more reactant particles into the mixture. If there are more reactant particles in the same space they collide more often with the other particles, so the rate increases. |
| **10** | **Explain, using the reacting particle model, why changes in concentration change the rate of reaction in terms of successful collisions between particles.** |  | **10** | **Increasing the concentration means putting more reactant particles into the mixture this causes more collisions. More collisions mean more effective collisions which mean a faster rate.** |
| 11 | Describe the effect of changing the pressure on the rate of a chemical reaction of gases. |  | 11 | Increasing the pressure in a gas is like increasing concentration. It increases the rate. |
| 12 | Explain, in terms of the reacting particle model, why changes in pressure change the rate of reaction. |  | 12 | Increasing the concentration means putting more reactant particles into the mixture. If there are more reactant particles in the same space they collide more often with the other particles, so the rate increases. |
| **13** | **Explain, using the reacting particle model, why changes in pressure change the rate of reaction in terms of successful collisions between particles.** |  | **13** | **More particles in the same space mean more collisions, which mean more successful collisions, which mean a faster rate.** |

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| **C3c** | Rate of reaction (3) |  | **C3c** | Rate of reaction (3) |
| 1 | How is the rate of a reaction changed by the addition of a catalyst? |  |  | The rate of a reaction is increased. |
| 2 | Describe a catalyst. |  |  | A substance which changes the rate of reaction and is unchanged at the end of the reaction |
| 3 | Why is only a small amount of a catalyst needed to catalyse large amounts of reactants? E.g. 1g of black manganese IV oxide powder will catalyse the break-up of 10 litres of hydrogen peroxide.  2H2O2(aq) 🡪 2H2O(l) + O2(g) |  |  | The hydrogen peroxide particles break-up on the surface of the black manganese IV oxide powder using a reaction route that has a lower activation energy than the normal route. As the MnO2 powder is not used up it can carry on until all the H2O2 is used up. |
| 4 | Why don’t other black powders, like charcoal and copper oxide, catalyse the break-up of hydrogen peroxide? |  |  | A catalyst is specific to a particular reaction. I.e. Manganese IV oxide is the catalyst for the break-up of H2O2 so no other black powders will work. |
| 5 | How can the rate of a reaction be changed by using a powdered reactant rather than a lump (or vice versa). |  |  | The rate of a reaction can be increased by using powders. |
| **6** | Explain the difference in rate of reaction between a lump and powdered reactant. |  |  | Lumps have a low surface area. Powders have a large surface area. More surface for the acid to get to too react. |
| 7 | **Explain, in terms of collisions between reacting particles, the difference in rate of reaction between a lump and powdered reactant.** |  |  | Reactions between solids and liquids happen at the surface of the powder. So, more surface area means more collisions which means more effective collisions which means faster rate. |
| 8 | Describe an explosion |  |  | A very fast reaction which releases a large volume of gaseous products. The sudden pressure build up caused by the high temperature compressed gas causes the explosions shock wave. |
| 9 | Explain the dangers of fine combustible powders in factories  (e.g. custard powder, flour or sulphur). |  |  | Custard powder is very flammable, it is mostly starch. As a fine powder it is very explosive. The sides of custard factories used to be made from sheets of corrugated iron hung on nails so that they could be put back quickly after an explosion. |
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| **C3d** | Reacting masses |  | **C3d** | Reacting masses |
| 1 | Calculate the relative formula mass of ammonium nitrate NH4NO3,  given that N=14, H=1,O=16 |  |  | 14+(1x4)+14 +(16x3) = 80 |
| 2 | Calculate the relative formula mass of ammonium sulphate, (NH4)2SO4,  given N=14, H=1,O=16,S=32. |  |  | (14+(1x4))x2 + 32x1+(16x4)  (18x2)+96 =128 |
| 3 | What is the principle of conservation of mass? |  |  | The total mass of reactants at the start of a reaction is equal to the total mass of products made |
| 4 | Use the principle of conservation of mass to calculate the mass of oxygen formed from 68g of hydrogen peroxide?  2H2O2(aq) 🡪 2H2O(l) + O2(g) |  |  | 2H2O2(aq) 🡪 2H2O(l) + O2(g)  68 2x18 32  32g of oxygen |
| 5 | What mass of oxygen reacts with 48g of magnesium to make magnesium oxide? |  |  | 2Mg + O2 🡪 2MgO  48 + 32 80  32g of oxygen |
| 6 | Show that mass is conserved during  **Mg + H2O 🡪 MgO + H2**  Where Mg=24, H=1, O=16 |  |  | **Mg + H2O 🡪 MgO + H2**  24 + 18 40 + 2  42 = 42 |
| 7 | Explain why mass is conserved in chemical reactions. |  |  | There are the same number of atoms on both sides of the balanced equation. |
| 8 | **Show that mass is conserved during**  **Mg + 2HCl 🡪 MgCl2 + H2**  **Given Mg-24, H=1, CL=35.5** |  |  | **Mg + 2HCl 🡪 MgCl2 + H2**  24 + 73 95 + 2  97 97 |
| 9 | Calculate the mass of oxygen formed from 3.4g of hydrogen peroxide?  2H2O2(aq) 🡪 2H2O(l) + O2(g) |  |  | 68 2x18 32  2H2O2(aq) 🡪 2H2O(l) + O2(g)  3.4g is 1/20th of 68 1/20th of 32 is 1.6g |
| 10 | What principle allows these quantitative calculations to be made? |  |  | The mass of product formed is directly proportional to the mass of limiting reactant used |
| 11 | **If I start with two lots of magnesium, how much of the products do I make?**  **Mg + 2HCl 🡪 MgCl2 + H2** |  |  | **Mg + 2HCl 🡪 MgCl2 + H2**  So  **2Mg + 4HCl 🡪 2MgCl2 + 2H2**  Two lots! |
| 12 | **If I start with two 0.24g of magnesium, how much of the products do I make?**  **Mg + 2HCl 🡪 MgCl2 + H2** |  |  | **24 + 73 95 + 2**  **Mg + 2HCl 🡪 MgCl2 + H2**  0.24g is 1/100th  So  ***1/100*Mg + *2/100*HCl 🡪 *1/100*MgCl2 + *1/100*H2** 0.95g+0.2g = 0.97g |
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| **C3e** | **Percentage yield and atom economy** |  | **C3e** | **Percentage yield and atom economy** |
| 1 | What is percentage yield? |  |  | Percentage yield is a way of comparing amount of product made (actual yield) to amount expected (predicted yield) |
| 2 | What is 100% percentage yield? |  |  | 100% yield means that no product has been lost |
| 3 | What is 0% percentage yield? |  |  | 0% yield means that no product has been made. |
| 4 | What possible reasons are there why the percentage yield of a product is less than 100% for example: |  |  | • loss in filtration  • loss in evaporation  • loss in transferring liquids  • not all reactants react to make product. |
| 5 | Recall the formula for percentage yield. |  |  | percentage = actual yield × 100  yield predicted yield |
| 6 | **Explain why an industrial process wants as high a percentage yield as possible, to include:** |  |  | **• reducing the reactants wasted**  **• reducing cost.** |
| 7 | What is atom economy? |  |  | Atom Economy is a way of measuring the amount of atoms that are wasted when manufacturing a chemical |
| 8 | What is 100% atom economy? |  |  | 100% atom economy means that all atoms in the reactant have been converted to the desired product |
| 9 | Why is atom economy green? |  |  | the higher the atom economy the greener the process. |
| 10 | Recall the formula for atom economy: |  |  | atom = Mr of desired products × 100  economy sum of Mr of all products |
| 11 | Calculate atom economy in the manufacture of oxygen gas here?  2H2O2(aq) 🡪 2H2O(l) + O2(g) |  |  | Atom economy = 32/68 x 100 = 47% |
| 12 | **Calculate atom economy in the manufacture of magnesium chloride**  **Mg + 2HCl 🡪 MgCl2 + H2** |  |  | **Atom economy = 95/97 x 100 = 98%** |
| 13 | **Explain why an industrial process wants as high an atom economy as possible:** |  |  | **To reduce the production of unwanted products**  **To make the process more sustainable.** |
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| **C3f** | **Energy** |  | **C3f** | **Energy** |
| 1 | What is an exothermic reaction? |  | 1 | One in which energy is transferred into the surroundings (releases energy). |
| 2 | What is an endothermic reaction? |  | 2 | One in which energy is taken from the surroundings (absorbs energy). |
| 3 | How do you recognise exothermic and endothermic reactions using temperature changes. |  | 3 | If the reaction gets hotter by itself it is exothermic. |
| 4 | Why is bond breaking as an endothermic process? |  | 4 | You need energy to pull the atoms apart |
| 5 | Why is bond making as an exothermic process? |  | 5 | You get a release of heat from the converted kinetic energy when a bond forms |
| **6** | **Explain why a reaction is exothermic or endothermic using the energy changes that occur during bond breaking and bond making.** |  | **6** | **If more bonds are formed than are broken then the reaction is exothermic.** |
| 7 | Describe, using a diagram, a simple calorimetric method for comparing the energy transferred in combustion reactions: |  | 7 | http://www.bbc.co.uk/schools/gcsebitesize/science/images/gatewaysci_04.gif |
| 8 | Describe a simple calorimetric method for comparing the energy transferred per gram of fuel combusted: |  | 8 | • use of spirit burner or a bottled gas burner  • heating known mass of water in a copper calorimeter  • measuring mass of fuel burnt  • measuring temperature change  • using fair and reliable tests. |
| 9 | Explain the energy transferred formula (no recall needed):  energy transferred (in J) = m × c × ΔT |  | 9 | • m = mass of water heated in grams  • c = specific heat capacity (4.2 J/g °C)  • ΔT = temperature change in degrees. |
| **10** | **Use the formula**  **energy transferred (in J) = m × c × ΔT**  **to find the energy change if 100g of water are heated by 80’C in a kettle.** |  | **10** | **energy transferred (in J) = m × c × ΔT**  **= 100 x 4.2 x 80**  **=33600J**  **=33.6 Kj** |
| **11** | **Calculate the energy output of a fuel in J/g by recalling and using the right formula. Where 5g of methane heats a litre of water by 50’C.** |  | **11** | **energy = energy released (in J)**  **per gram mass of fuel burnt (in g)**  **energy = 1000 X 4.2 X 50**  **per gram 5**  **energy = 42,000J per g or 42Kj per g** |
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| **C3g** | Batch or continuous? |  | **C3g** | Batch or continuous? |
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| 1 | Describe the differences between a batch and a continuous process. |  | 1 | A batch process runs from start-up to shutdown. A continuous process runs all the time |
| 2 | Explain why batch processes are often used for the production of drugs, pharmaceutical drugs. |  | 2 | Pharmaceutical drugs are often only needed is small amounts made by a small team of well qualified staff. |
| 3 | Why are continuous processes are used to produce chemicals such as ammonia. |  | 3 | Fertilisers are needed in bulk and can be made by an automated process. |
| 4 | List the factors that affect the cost of making and developing a pharmaceutical drug: |  | 4 | • research and testing  • labour costs  • energy costs  • raw materials  • time taken for development  • marketing. |
| 5 | Explain why pharmaceutical drugs need to be thoroughly tested before they can be licensed for use. |  | 5 | They will be used on people, sick people. So they need thorough testing to identify side effects. |
| 6 | Explain why it is often expensive to make and develop new pharmaceutical drugs. |  | 6 | • research and testing  • labour costs  These may run over 20 years before the drug is marketable |
| **7** | **Explain why it is difficult to test and develop new pharmaceutical drugs that are safe to use.** |  | **7** | **The human body is complex. There are many complex interactions. Drugs may cause side effects in the long term so testing must be rigorous.** |
| 8 | Recall that the raw materials for speciality chemicals such as pharmaceuticals can be either made synthetically or extracted from plants. |  | 8 | On the small scale, plant extracts can be used. Large scale requires bulk production and that usually means synthetic sources |
| 9 | Describe how chemicals are extracted from plants: |  | 9 | • crushing  • boiling and dissolving in suitable solvent  • chromatography. |
| 10 | Explain why it is important to manufacture pharmaceutical drugs to be as pure as possible. |  | 10 | Impurities can cause side effects |
| 11 | Describe how melting point, boiling point and thin layer chromatography can be used to establish the purity of a compound. |  | 11 | Pure compounds have fixed melting points and boiling points. Impurities change them.  Pure compounds give single pigment separation on TLC. |
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| **C3h** | **Allotropes of carbon and nanochemistry** |  | **C3h** | **Allotropes of carbon and nanochemistry** |
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| 1 | Explain why diamond, graphite and Buckminster fullerene are all forms of carbon. |  | 1 | They are all made of carbon atoms, they are pure carbon |
| 2 | Recognise the structures of diamond, graphite and buckminster fullerene. |  | 2 | Diamond is a pyramid, graphite is layers and bucky balls are, well, balls. |
| 3 | Explain why diamond, graphite and fullerenes are allotropes of carbon. |  | 3 | Allotropes are different physical forms of the same element. |
| 4 | List the physical properties of diamond: |  | 4 | • lustrous, colourless and clear (transparent)  • hard and has a high melting point  • insoluble in water  • does not conduct electricity. |
| 5 | Explain, in terms of properties, why diamond is used in cutting tools and jewellery. |  | 5 | Diamond is the hardest natural substance in the world, hence cutting tools. It is lustrous, sparkly and hard-wearing. |
| **6** | **Explain, in terms of structure and bonding, why diamond:**  **• does not conduct electricity**  **• is hard and has a high melting point.** |  | **6** | **No free electrons, all are locked up in covalent bonds.**  **Four strong covalent bonds link each atom and take a lot of energy to break.** |
| 7 | List the physical properties of graphite: |  | 7 | • black, lustrous and opaque  • slippery  • insoluble in water  • conducts electricity. |
| 8 | Explain, in terms of properties, why graphite is used:  • in pencil leads  • in lubricants. |  | 8 | The layers slip off each other and stick to the paper.  The layers slip over one another easily and act as a lubricant. |
| **9** | **Explain, in terms of structure and bonding, why graphite:**  **• conducts electricity**  **• is slippery**  **• has a high melting point.** |  | **9** | **The layers are held by weak bonds which contain delocalised but free electrons, hence slippery conduction.**  **Within the layers the atoms are held tightly by three strong covalent bonds.** |
| 10 | Explain why diamond and graphite have a giant molecular structure. |  | 10 | They are covalent structures that are able to extend indefinitely, hence giant molecules. |
| **11** | **Predict and explain the properties of substances that have a giant molecular structure.** |  | **11** | **High mpts and bpts.**  **Insulators**  **Solids**  **Strong**  **Insoluble ….. think rock** |
| 12 | Recall that nanotubes are used to reinforce graphite in tennis rackets because nanotubes are very strong. |  | 12 | Nanotubes were once called carbon fibres and used for their strength and lightness. |
| 13 | Recall that nanotubes are used as semiconductors in electrical circuits. |  | 13 | Nanotubes can be made to conduct under certain circumstances, hence semi-conductors |
| 14 | Explain why fullerenes can be used in new drug delivery systems. |  | 14 | The insoluble drugs are wrapped in the fullerene tubes or balls. These are soluble |
| **15** | **Explain how the structure of nanotubes enables them to be used as catalysts.** |  | **15** | **The nanotubes can also hold metal atoms as catalysts.** |