Scheme of work

Combined Science: Synergy

Movement and interactions

This resource provides guidance for teaching the Movement and interactions topic from our new GCSE in Combined Science: Synergy (8465). It has been updated from the draft version to reflect the changes made in the accredited specification. Changes have been made to required practical activities and there have been minor changes in the specification content in sections 4.7.1.4 Free fall, 4.7.1.6 Newton's second law, 4.7.2.2 Current, resistance and potential difference, 4.7.2.3 Series and parallel circuits, 4.7.2.9 The National Grid, 4.7.3.1 Reactions of acids, 4.7.3.2 Making salts, 4.7.3.3 Energy changes and reactions, 4.7.3.4 Hydrogen ions and the pH scale, 4.7.3.5 Strong and weak acids, 4.7.4.3 The effect of temperature, concentration and pressure on rates of reaction, 4.7.4.4 Activation energy, 4.7.4.7 Enzymes, 4.7.4.8 Reversible reactions, 4.7.5.1 A reactivity series for metals, 4.7.5.2 Electrolysis, 4.7.5.3 Electrolysis of aqueous solutions, 4.7.5.4 Tests for gases and 4.7.5.5 Electron transfer reactions.

The scheme of work is designed to be a flexible medium term plan for teaching content and development of the skills that will be assessed.

It is provided in Word format to help you create your own teaching plan – you can edit and customise it according to your needs. This scheme of work is not exhaustive; it only suggests activities and resources you could find useful in your teaching.

4.7 Movement and interactions

4.7.1 Forces and motion

Spec ref.	Summary of the specification content	Learning outcomes *What most candidates should be able to do*	Suggested timing (hours)	Opportunities to develop Scientific Communication skills	Opportunities to apply practical and enquiry skills	Self/peer assessment Opportunities and resources *Reference to past questions that indicate success*
4.7.1.1	Distance is how far an object moves. Distance does not involve direction. Distance is a scalar quantity. Displacement includes both the distance an object moves, measured in a straight line from the start point to the finish point and the direction of that straight line. Displacement is a vector quantity. Speed does not involve direction. Speed is a scalar quantity. The velocity of an object is its speed in a given direction. Velocity is a vector quantity.	Define distance. Define displacement. Explain the difference between distance and displacement. Explain the difference between scalars and vectors and state which distance and displacement are.	1	Analyse both a 100 m race and a 400 m (one round an oval track) race. Look at how the distance and displacement changes for each race. Discussion questions: • What is the difference between distance and displacement? • If I complete a complete lap of a 400 m track have I gone anywhere?	Investigate how the distance travelled by a person and their displacement is usually different. This can be done by a modelling activity. For example, students walk 4 m in a straight line and then turn left and walk a further 5 m. What distance have they moved and what is their displacement? This can be done both mathematically and by taking direct measurements.	What are Distance, Displacement, Speed and Velocity? BBC Bitesize – Speed, velocity and acceleration Exampro user guide PowerPoint

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4.7.1.1	The speed of a moving object is rarely constant. When people walk, run or travel in a car their speed is constantly changing. The speed that a person can walk, run or cycle depends on many factors, including age, terrain, fitness and distance travelled. Typical mean values are: • walking 1.5 m/s • running 3 m/s • cycling 6 m/s. It is not only moving objects that have varying speed. The speed of sound and the speed of the wind also vary. A typical value for the speed of sound is 330 m/s.	Define speed and calculate it by using $speed = \frac{distance}{time}$ State that speed is a scalar quantity. Describe the difference between average speed and instantaneous speed. Explain why the speed of a moving object is nearly always changing. Describe and explain the factors that affect how quickly a person can walk or run. State typical walking, running and cycling speeds in m/s.	0.5	Discussion questions • What is the speed of sound? • What factors change the speed of sound? • Can we measure the speed of sound in school? Research the speed of sound and the factors that affect it.	How fast do people walk and run? Students are timed walking a known distance and then their speed is calculated. This can then be extended to them running the same distance so their times can be compared. How can we find out if cars on the road are speeding? Investigate the speed of vehicles on roads – this can also be done with trolleys in a lab using data loggers and light gates. Research methods used by the police/ council to determine whether motorists are speeding.	What Is the Speed of Sound? Sound Speed Teachit Science resource (20195) 'Speed of sound'

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		State that the speed of sound is not a fixed value as it depends on the temperature and humidity. Describe examples of where wind speed changes, eg a summer breeze to a hurricane.			Find the speed of sound by measuring the time taken for an echo to get back to you after clapping your hands or banging two large lumps of wood together, near a wall. The distance to the wall will need to be measured (and doubled to find the distance the sound wave travels).	
4.7.1.2	The distance travelled by an object moving at constant speed increases with time. distance travelled = speed × time $s = v t$ distance, *s*, in metres, m speed, *v*, in metres per second, m/s	State the equation used to find the speed of an object. Calculate the speed of an object given the distance travelled and the time taken. Rearrange the equation to find either unknown quantity.	0.5	Analyse data about vehicle/animals travelling with different speeds, distances and times to find which object is travelling the fastest or will travel the greatest distance in a given time. Explain how the speed of a vehicle can be found experimentally.	Experiment detailed above in 'Definition of Speed'. What do the different types of line on a distance–time graph represent? How can I tell where a vehicle is moving fastest	BBC Bitesize – speed, distance and time YouTube: Distance-time graphs & speed Displacement – Time Graphs

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	time, *t*, in seconds, s If an object moves along a straight line, how far it is from a certain point can be represented by a distance–time graph. The speed of an object can be calculated from the gradient of its distance–time graph. (HT only) If an object is accelerating, its speed at any particular time can be determined by drawing a tangent and measuring the gradient of the distance–time graph at that time.	Draw and interpret distance–time graphs. Calculate the speed of an object from a distance–time graph. Calculate the speed of an object that is accelerating from a distance – time graph by finding the tangent to the curve at a given point then finding the gradient of the tangent.		How does a sat nav predict the time taken to reach home? If a satellite is moving at 30 000 mph how far does it travel in a day, week, year? Compare the distance travelled by two trolleys moving at different speeds. Which travels the furthest in a given time? If the speed is double what will happen to the distance travelled? Compare the speeds of two or more objects, or from one object at different points, on a distance–time graph from the gradients of the lines. State that the steeper the line on a distance-time graph the faster the object is travelling. MS 3b, 3c	on a distance–time graph? How can the distance decrease on a distance–time graph when the distance travelled has increased? Draw distance–time graphs of a journey described by another person. Alternatively, draw a distance–time graph of your journey into school and get another person to describe the journey – peer assess to see if the description is accurate. Alternatively, you could model this outside by having students moving between certain points	BBC Bitesize Force and momentum BBC Bitesize – Analysing motion: Revision

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				Recall and apply this equation. MS 1c, 3b, 3c Use ratios and proportional reasoning to convert units and to compute rates. WS 1.2, MS 4a, 4b, 4c, 4d, 4f Relate changes and differences in motion to appropriate distance–time, and velocity–time graphs, and interpret lines, slopes and enclosed areas in such graphs. MS 1a, 1c, 2f Calculate average speed for non-uniform motion.	and the time to do that recorded as well as the distance between the points. Then back in the classroom this data can be displayed on a distance–time graph.	
4.7.1.3	(HT only) The velocity of an object is its speed in a given direction. Velocity is a vector quantity.	Explain why an object travelling around a circular track may have a constant speed	0.5	Why is direction important when looking at collisions? Does a negative velocity mean that the vehicle is reversing?		

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	When an object moves in a circle the direction of the object is continually changing. This means that an object moving in a circle at constant speed has a continually changing velocity.	but a constantly varying velocity. Show that the average velocity of an object around a circular track is 0 m/s.		When an object moves round a track at a steady speed why is the average velocity 0 m/s (uses idea of displacement)?		
4.7.1.4	Acceleration is the rate at which the velocity of an object changes. acceleration = change in velocity ÷ time taken $a = \Delta v \div t$ acceleration, *a*, in metres per second squared, m/s^2 change in velocity, Δv, in metres per second, m/s time, *t*, in seconds, s	Define acceleration. Calculate the acceleration of a vehicle when given the initial and final speed and the time taken for the change in speed to occur. Rearrange the equation to find other unknown quantities. Define deceleration as negative acceleration. Explain what negative acceleration means,	0.5	Why do motorcycles have a greater acceleration than cars even though the engine is usually much smaller? Discussion questions: • Why is acceleration important in a car crash? • How can we find the acceleration of an object? • What happens to a moving object when the acceleration becomes zero? • What factors affect the deceleration of a vehicle?	Investigate the acceleration of a trolley in a lab using ticker tape or light gates.	BBC Bitesize Acceleration

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	An object that slows down (decelerates) has a negative acceleration. The acceleration of an object can be calculated from the gradient of a velocity–time graph. The distance travelled by an object can be calculated from the area under a velocity–time graph.	eg an acceleration of -1.5 m/s^2.		WS 1.2, MS 3b, 3c Recall and apply this equation. WS 1.2, MS 4a, 4b, 4c, 4d, 4f, 5c Relate changes and differences in motion to appropriate velocity– time graphs, and interpret lines, slopes (HT only) and enclosed areas in such graphs.		
4.7.1.4 cont.	(HT only) The following equation applies to uniform motion: (final velocity)^2 – (initial velocity)^2 = 2 × acceleration × distance $[v^2 - u^2 = 2 a s]$	Use the equation to find any unknown given the other values. Interpret questions to find values not specifically stated, eg starts at rest means an initial velocity of 0 m/s.	1	How does the acceleration of a skydiver change through a jump? If a skydiver opens their parachute and decelerates does this mean they go upwards as when a car decelerates it does not go backwards?		BBC Bitesize – Falling objects Speed and Velocity Free Fall and Air Resistance

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	final velocity, v, in metres per second, m/s initial velocity, *u*, in metres per second, m/s acceleration, *a*, in metres per second squared, m/s^2 distance, *s*, in metres, m Near the Earth's surface any object falling freely under gravity has an acceleration of about 9.8 m/s^2 An object falling through a fluid initially accelerates due to the force of gravity. Eventually the resultant force will be zero and the object.	Describe why objects near the Earth's surface fall. Describe how the forces acting on skydiver change throughout a sky dive – from jumping out of the plane to landing on the floor.		What does uniform motion mean? In what situations would I use $v^2 - u^2 = 2\,a\,s$ rather than $speed = \frac{distance}{time}$? How does the speed a parachute falls at depend on the size of the parachute? How does the weight on a parachute affect how quickly it falls? WS 1.2, MS 3c Appply this equation, which is given on the equation sheet.		
4.7.1.5	Newton's First Law: If the resultant force acting on an object is zero and:	State Newton's First Law.	0.5	Newton's First Law seems to say that if I throw an object it will keep moving in a straight	Do bigger engines in vehicles mean a higher top speed?	Newton's First Law Newton's First Law of Motion

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	• the object is stationary, the object remains stationary • the object is moving, the object continues to move at the same speed and in the same direction. So the object continues to move at the same velocity.	Describe the effect of having no resultant force on: • a stationary object • an object moving at a constant velocity. Explain that for an object travelling at terminal velocity the driving force(s) must equal the resistive force(s) acting on the object.		line and at a steady speed but it doesn't. Why? What are the forces acting on a skydiver at terminal speed? Why do cars have a top speed?	Find out if there is a correlation between the size of a vehicles engine and its top speed? Look at motorcycles, cars and articulated lorries.	
4.7.1.6	Newton's Second Law: The acceleration of an object is proportional to the resultant force acting on the object, and inversely proportional to the mass of the object.	State Newton's Second Law. Calculate the resultant force acting on an object using the equation.	0.5	Questions for students to consider: • What makes objects accelerate? • How can a car accelerate if it is moving around a circle at a steady speed?	Investigate how the mass of a trolley affects its acceleration. Use light gates or ticker tape to take accurate measurements and add mass to the trolley.	Newton's Second Law Newton's Second Law of Motion Inertia and Mass

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	resultant force = mass × acceleration $F = m a$ force, F, in newtons, N mass, m, in kilograms, kg acceleration, a, in metres per second squared, m/s^2 (HT only) The tendency of objects to continue in their state of rest or of uniform motion is called inertia. Inertial mass is a measure of how difficult it is to change the velocity of an object. Inertial mass is defined by the ratio of force over acceleration.	Rearrange the equation to find any other unknown quantity. Analyse data on vehicles to determine the acceleration when given the driving force and mass of the vehicle. Explain why two identical cars that have different loads will have different accelerations. Explain why heavier vehicles have greater stopping distances than light vehicles, assuming the same braking force.		• What determines how quickly a vehicle accelerates? • Why does a ball falling through a liquid have a lower acceleration than a ball falling through air? • Why is it harder to turn a loaded shopping trolley than an empty one? (HT only) • How does the mass of a vehicle affect its acceleration? • Why do motorcycles have a greater acceleration than cars? • Why do cars have a higher top speed than motorcycles even though the motorcycle has less mass?	Investigate how the driving force of a trolley affects its acceleration. Add more mass to the pulley to change the driving force. Use light gates or ticker tape to take accurate measurements and add mass to the trolley. **Required practical 14:** investigate the effect of varying the force on the acceleration of an object of constant mass and the effect of varying the mass of an object on the acceleration produced by a constant force. Physics AT 1, 2 and 3	

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		(HT only) Define inertial mass. (HT only) Explain why it is difficult to get a heavy moving object to change speed and/or direction but not a light one.				
4.7.1.7	Newton's Third Law: Whenever two objects interact, the forces they exert on each other are equal and opposite.	State Newton's Third Law. Draw force diagrams to show Newton's third law, eg a falling object being pulled down by gravity and the Earth being pulled by the falling object. Forces need to be equal in size and opposite in direction.	0.5	Why do my feet hurt when I have been standing up for a long time? If I drop a ball it is pulled down but is the Earth pulled up? Do forces always act in pairs? Why do guns and cannons recoil when fired?	Students can be asked to come up with their own demonstrations, eg leaning on a wall with one hand, getting off a skateboard, etc.	Newton's Third Law Newton's Third Law of Motion

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4.7.1.8	(HT only) Momentum is a property of moving objects. Momentum is defined by the equation: momentum = mass × velocity $p = m v$ momentum, *p*, in kilograms metre per second, kg m/s mass, *m*, in kilograms, kg velocity, *v*, in metres per second, m/s In a closed system, the total momentum before an event is equal to the total momentum after the event. This is called conservation of momentum.	Define momentum and recall it is a vector quantity. State the equation that links momentum, mass and velocity. Calculate the momentum of an object. Rearrange the equation to find any unknown quantity. State the units of momentum. Calculate the momentum of an object given its mass, speed and direction of movement. Explain the importance of the minus sign for a numerical velocity in	1	Discussion questions: • Why is it easier stop a tennis ball than a football travelling at the same speed? • Why does the direction of a vehicle matter in a collision? • How can police investigators determine the speed of vehicles before a crash? • How does an explosion conserve momentum? • How do rockets take off? Carry out conservation of momentum calculations for systems involving two objects, including collisions and explosions. WS 1.2, MS 3c	Demonstration of collisions along an air track to show the effect of different types of collisions or explosions. This can also be done with trolleys with a spring causing the explosion. Change the mass of each trolley to see the effect on the speed at which they move apart.	BBC Bitesize – Conservation of momentum Conservation of Momentum Teachit Science resource (23218) 'Momentum revision'

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		the calculation of momentum. Explain what is meant by a closed system. Explain what is meant by conservation of momentum.		Recall and apply this equation. WS 1.2 Use the concept of momentum as a model to analyse an event such as a collision.		
4.7.1.9	The kinetic energy of a moving object depends on the mass and the velocity of the object. kinetic energy = 0.5 × mass × (speed)^2 [$E_k = ½\ m\ v^2$] kinetic energy, E_k , in joules, J mass, *m*, in kilograms, kg speed, *v*, in metres per second, m/s	Calculate the kinetic energy of a moving object using the equation: kinetic energy = 0.5 × mass × (speed)^2 [$E_k = ½\ m\ v^2$]	0.5	WS 1.2, MS 3c Recall and apply this equation. Why are rugby forwards usually large and heavy? Why is it difficult to stop a forward running at full speed? Students list sports in which kinetic energy is an important factor.	Provide opportunities for students to convert units when applying the equation. Students research the mass and speed of various mammals and design their own questions involving the calculation of kinetic energy. Students explain how they would investigate the relationship between	Upd8 resource 'Think 30 for a reason'

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					kinetic energy, speed and mass. What effect does increasing speed have on kinetic energy? Draw a graph to illustrate.	
4.7.1.10	The stopping distance of a vehicle is the sum of the distance the vehicle travels during the driver's reaction time (thinking distance) and the distance it travels under the braking force (braking distance). For a given braking force the greater the speed of the vehicle, the greater the stopping distance. The braking distance of a vehicle can be affected by wet or icy weather and poor condition	Define: • thinking distance • braking distance • stopping distance. State that the overall stopping distance of a vehicle is made up of the thinking distance plus the braking distance. Describe and explain how the speed of a vehicle affects the	0.5	Discussion questions: • Why should a 2-second gap be left between vehicles on the road? • How will being tired affect my reaction time and thinking distance? • Why does the speed of a vehicle affect the thinking distance even though it takes the same amount of time to react? • How do drugs affect reaction times?	Investigate how speed changes the stopping distance using a ramp set to different heights and a sand trap at the bottom of the ramp. Record the distance the car travels in the sand trap before coming to rest. Research how the reaction time of a person can be affected	BBC Bitesize – Stopping distances BBC Bitesize – Thinking, braking and stopping distance Video clip: Stopping distances RoSPA's Stopping distance simulator

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	of the vehicle's brakes or tyres. A driver's reaction time can be affected by tiredness, drugs and alcohol. Distractions may also affect a driver's ability to react.	stopping distance, for a given braking force. Estimate the typical reaction times of a person. Describe and explain how drugs will affect a driver's reaction time and thinking distance. Explain how thinking distance and reaction time are linked.		• How does reaction time affect thinking distance? • How can reaction time be found? • Does using a mobile phone when driving affect reaction time? Describe methods of measuring the reaction time of a driver. Analyse data on reaction times and use this to estimate the thinking distance of a driver. WS 3.6 Analyse a given situation to explain why braking could be affected. Creative writing: Produce a leaflet to encourage motorists to switch off mobile phones before driving.	by various factors including: • drugs (use caffeinated drinks) • distractions • tiredness.	

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				Task can be changed to look at the effects of drink driving/drug driving or to encourage the use of 20 mph zones around schools. Each task would need to link back to the effect that each has on reaction time and thinking distance. Find patterns between the speed of a vehicle and the thinking distance, eg what would be the effect of doubling the speed on the thinking distance and why? WS 1.5 Discuss the implications for safety. MS 4a		

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				Interpret graphs relating speed to stopping distance for different types of vehicles. WS 1.5, 2.2, MS 1a, 1c Evaluate the effect of various factors on thinking distance based on given data.		
4.7.1.10 cont.	When a force is applied to the brakes of a vehicle, work done by the friction force between the brakes and the wheel reduces the kinetic energy of the vehicle and the temperature of the brakes increases. The greater the speed of a vehicle the greater the braking force needed to stop the vehicle in a certain distance.	Describe and explain the energy changes involved in stopping a vehicle. Explain why vehicles travelling faster have larger braking distances.	0.5	Find patterns between the speed of a vehicle and the braking distance, eg what would be the effect of doubling the speed on the braking distance and why? Explain why stopping from high speed can cause the brake pads to overheat and the brake disks to warp. WS 1.5, MS 1d	Discussion questions: • Why does a drawing pin heat up when rubbed across a surface? • Why do the rims of bicycles get hot when going down steep hills? • What problems are caused by brakes overheating on bicycles and cars?	

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	The greater the braking force the greater the deceleration of the vehicle. Large decelerations may lead to brakes overheating and/or loss of control.			(HT only) estimate the forces involved in typical situations on a public road.	• Why are the brakes for a Formula 1 car not suitable for road use? • Why do cars skid and why do the skid more on wet roads? Research why vehicles skid on the road ensuring this is linked to the level of friction between the tyre and the road and the braking force applied.	

4.7.2 Electricity

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4.7.2.1	For electrical charge to flow through a closed circuit the circuit must include a source of potential difference. Electric current is a flow of electrical charge. The size of the electric current is the rate of flow of electrical charge. charge flow = current × time [$Q = I\ t$} charge flow, Q, in coulombs, C current, I, in ampere, A time, t, in seconds, s. The current at any point in a single closed loop of a circuit has the same value as the current at any other point in the same closed loop.	State the name of the particle that usually carries the electrical charge round a circuit. Define potential difference.	1	Ask questions such as: • What is an electric current? • Which particle moves in an electric current? • What makes the particle move? MS 3b, 3c Recall and apply this equation.	Demonstrate models of electricity and discuss what each part of the model represents and what makes the particles move. Examples could include the rope model, sweets model, water flow model, etc.	BBC Bitesize – Current, voltage and resistance Pass My Exams – Electric Current Cyberphysics – Electric Current

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4.7.2.2	The current through a component depends on both the resistance of the component and the potential difference across the component. The greater the resistance of the component the smaller the current for a given potential difference (p.d.) across the component. potential difference = current × resistance [$V = I R$] potential difference, V, in volts, V current, I, in amperes, A resistance, R, in ohms, Ω	Define resistance. Describe and explain how increasing the resistance in a circuit will affect the current flowing through the circuit. Use the equation to calculate the potential difference (voltage), current or resistance when given the other two values. State the correct SI units for each quantity (potential difference, current and resistance).	1	What is resistance? Why are materials with low resistance chosen for power cables? What are superconductors? Research what superconductors do and what they are made from. How can the resistance of a component be calculated using the current and potential difference? Why does increasing the voltage in a circuit also increase the current flowing through it? What is meant by resistance? Find the resistance of some electrical components using	Model the effect of resistance on a circuit. You can do this with clear tubing and coloured water to act as the current. Pinch the tubing to show higher resistance. Investigate how increasing the resistance of a circuit affects the current flowing.	BBC Bitesize – Resistance BBC Bitesize – Current, voltage and resistance Cyberphysics – Resistances in series and in parallel Pass My Exams – Electrical Circuits, Resistance BBC Bitesize – Measuring resistance Cyberphysics – Basic electricity – Simple circuits Teachit Science resource (19974) ‘Which fuse?’

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				current and potential difference readings. MS 3c Recall and apply this equation. Questions will be set using the term potential difference. In answers, correct use of either potential difference or voltage is acceptable. The abbreviation amp is acceptable for ampere. Physics AT 6, 7		
4.7.2.2 cont.	The current through an ohmic conductor (at a constant temperature) is directly proportional to the potential difference across the conductor. This means that the resistance remains constant as the current changes.	Define what is meant by an ohmic conductor. What components are ohmic conductors? Describe the conditions for which Ohm's law is valid.	1	Explain why Ohm's law is not valid when the temperature of the conductor increases in terms of collisions. Draw the I–V graph for an ohmic conductor. Explain the shape of the I–V graph of the ohmic conductor.	Find the resistance of a resistor by experiment. Plot an I–V graph for the resistor, disconnecting the power supply unit between readings to let the wire cool down. Calculate the resistance from the graph and compare with the known	Thy Physics Classroom – Ohm's Law Pass My Exams – Ohm's Law

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					value from the colour coding on the resistor.	
4.7.2.2 cont.	The resistance of components such as lamps, diodes, thermistors and LDRs is not constant; it changes with the current through the component. The resistance of a filament lamp increases as the temperature of the filament increases. The current through a diode flows in one direction only. The diode has a very high resistance in the reverse direction. The resistance of a thermistor decreases as the temperature increases.	Explain that in other types of resistor the value of *R* can change as the current changes. Explain the design and use of circuits to explore such effects – including lamps, diodes, thermistors and light-dependent resistors (LDRs).	2	Draw the V–I graphs for a filament lamp and a diode. Explain the shape of the resulting graph in terms of resistance and current. Draw graphs to show how the resistance of an LDR will vary with light intensity and of a thermistor with temperature. Why do the current-voltage graphs for diodes and filament lamps look different to that of an ohmic conductor? Calculate the resistance of an LDR or a thermistor given the range of resistances for that component and the conditions that it is placed in.	**Required practical 15:** use circuit diagrams to construct appropriate circuits to investigate the I–V characteristics of a variety of circuit elements including a filament lamp, a diode and a resistor at constant temperature. Physics AT 6, 7 **Required practical 16:** use circuit diagrams to set up and check appropriate circuits to investigate the factors affecting the resistance of electrical circuits. This should include:	BBC Bitesize – Resistance graphs Cyberphysics – Characteristic Curves Pass My Exams – Ohm's Law Teachit Science resource (19977) 'Electricty – interpreting graphs' BBC Bitesize – Thermistors and LDRs Pass My Exams – Diodes, LDRs and Thermistors Cyberphysics – Diodes

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	The resistance of an LDR decreases as light intensity increases.			Describe and explain real-world applications of thermistors and LDRs including thermostats and switching on lights when it gets dark. Candidates should also be able to draw an appropriate circuit, using correct standard symbols, to carry out the real world applications. WS 1.2, MS 4c, 4d, 4e Use graphs to determine whether circuit components are linear or non-linear and relate the curves produced to the function and properties of the component. Questions will be set using the term potential difference. In answers, correct use of either potential difference or voltage is	•the length of a wire at constant temperature •combinations of resistors in series and in parallel. Physics AT 1, 6 and 7.	Cyberphysics – Thermistor

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				acceptable. The abbreviation amp is acceptable for ampere.		
4.7.2.3	There are two ways of joining electrical components: in series and in parallel. Some circuits include both series and parallel parts.	Describe the differences between series and parallel circuits.	1	Draw circuit diagrams for components connected in series and in parallel. Describe how ammeters and voltmeters are connected into a circuit. Why are fairy lights for Christmas trees connected in parallel and not series? Why does adding light bulbs in series make them all dimmer?		BBC Bitesize – Series and parallel circuits Pass My Exams – Conventional Current & Electron Flow Cyberphysics – Basic electricity – Simple circuits
4.7.2.3 cont.	For components connected in series: • there is the same current through each component • the total potential difference of the power supply is shared between the components	Define the term resistance. Explain why the current through each component in a series circuit is the same.	1	Why does the current stay the same throughout a series circuit but the potential difference drops? Why does adding more bulbs in series cause the current to decrease?	Investigate series circuits to find out how adding resistance, in the form of a variable resistor, changes the current and the potential difference in the circuit.	Properties of series and parallel circuits – Studyphysics! PDF Cyberphysics – Resistances in Series and in Parallel

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	• the total resistance of two components is the sum of the resistance of each component. $R_{total} = R_1 + R_2$ resistance, R, in ohms, Ω	Calculate the currents, potential differences and resistances in d.c. series circuits. Describe how the potential difference of the power supply is shared between the components and that the share of the potential difference a component receives depends on the resistance of that component. Calculate the resistance or two components in a circuit using $R_{total} = R_1 + R_2$		What is resistance? Use the concept of equivalent resistance. Apply knowledge of series circuits to real world applications. Students should be able to explain the design and use of d.c. series circuits for measurement and testing purposes. MS 1c, 3b, 3c, 3d Solve problems for circuits which include resistors in series using the concept of equivalent resistance. MS 1c, 3b, 3c, 3d Calculate the currents, potential differences and		

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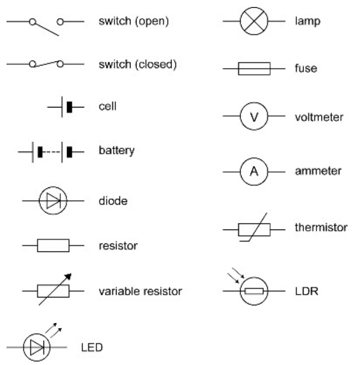
				resistances in d.c. series circuits.		
4.7.2.3 cont.	For components connected in parallel: • the potential difference across each component is the same • the total current through the whole circuit is the sum of the currents through the separate components • the total resistance of two resistors is less than the resistance of the smallest individual resistor.	State that the potential difference across each component in a parallel circuit is the same. Describe how the currents in different parts of a parallel circuit change and give the reasons for this change. Describe the effect on the resistance of adding resistors in parallel. State that adding resistors in parallel will make the total resistance less than	1	Describe the differences between series and parallel circuits in terms of current and potential difference. Students are not required to calculate the total resistance of resistors placed in parallel. Why does adding resistors in parallel reduce the resistance of the circuit compared to adding resistors in series? How does the current vary in each loop of a parallel circuit? Calculating the total resistance of two resistors joined in parallel is not required.	Investigate how the current in each loop of a parallel circuit compares to the current in the main branch of the circuit. Investigate the effect of adding two resistors in series in a simple circuit, then adding the same resistors in parallel in the same circuit. Find the resistance of three resistors in parallel by experimental methods.	Properties of series and parallel circuits – Studyphysics! PDF Cyberphysics - Resistances in Series and in Parallel

Spec ref.	Summary of the specification content	Learning outcomes *What most candidates should be able to do*	Suggested timing (hours)	Opportunities to develop Scientific Communication skills	Opportunities to apply practical and enquiry skills	Self/peer assessment Opportunities and resources *Reference to past questions that indicate success*
		the lowest value resistor.				
4.7.2.4	Circuit diagrams use standard symbols. 	Recall circuit symbols. Identify circuit symbols used in a circuit. Construct circuit diagrams using standard symbols.	0.5	Ask questions such as: • Why are circuit symbols used? • How are the electrical components connected together to form a circuit? • Where does the energy in a circuit come from? Play a pairs game or bingo with electrical symbols.	Set up simple circuits from circuit diagrams. Circuits need to include voltmeters and ammeters so that students are aware of how these devices are connected.	BBC Bitesize – Circuit symbols Teachit Science resource (19979) 'Electricity – pairs game'
4.7.2.5	Cells and batteries supply current that always passes in the same direction. This is called direct current (d.c.). An alternating current (a.c.) is one that changes direction. In the UK a.c. supply the	Describe the flow of electrons in a d.c. circuit as being in one direction only. State some common sources of a direct current including cells,	1	What is the difference between a.c. and d.c.? What are common sources of a.c. and d.c.? Research the use of a.c. and d.c. Find out why the USA used d.c. then changed to a.c.	Use an oscilloscope to display a.c. and d.c. signals.	BBC Bitesize – Direct current and alternating current Cyberphysics – AC/DC Pass My Exams – Direct Current (dc)

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	current changes direction 50 times per second.	batteries and solar cells. Describe the flow of electrons in an a.c. circuit as moving backwards and forwards. Describe mains electricity in the home in terms of potential difference, frequency and type of current.				and Alternating Current (ac)
4.7.2.6	Most electrical appliances are connected to the mains using three-core cable. The insulation covering each wire is colour coded for easy identification. • Live wire – brown • Neutral wire – blue	Describe the construction of a three core electric cable. State the name, the colour of the wire and the function of each wire in a three-core cable.	1	Why are fuses in plugs? What do the numbers on a fuse mean? Why are circuit breakers used if there is already a fuse in a plug?		Colours and functions of each wire in a three core cable – BBC Bitesize Wiring a plug Pass My Exams – The Three Pin Plug Cyberphysics – 3-Pin Plug

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	• Earth wire – green and yellow stripes The live wire carries the alternating potential difference from the supply. The neutral wire completes the circuit. The earth wire is a safety wire to stop the appliance becoming live. The potential difference between the live wire and earth (0 V) is about 230 V. The neutral wire is at or close to earth potential (0 V). The earth wire is at 0 V; it carries a current only if there is a fault. Our bodies are at earth potential (0 V). Touching the live wire produces a large potential difference across our body. This causes a	Match the name, colour and function of each wire. Describe the potential difference in the live wire with respect to earth. Describe how the earth wire acts as a safety wire and only carries a current if there is a fault. State that the resistance of the earth wire is low and that it will allow a large current to flow through it.		Why do some electrical cables only have two wires, and which wires are in them? Find out why plugs in Europe only have two pins compared to the three pin plugs in the UK. Find out why the top pin on some plugs, eg some mobile phone chargers, is made out of plastic. How do the fuse and earth wire work together to prevent electrocution? WS 1.5 Identify an electrical hazard in a given context.		

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	current to flow through our body, resulting in an electric shock.					
4.7.2.7	Power is defined as the rate at which energy is transferred or the rate at which work is done. power = energy transferred ÷ time *[P = E ÷ t]* Power = work done ÷ time [*P* = *W* ÷ *t*] power, *P*, in watts, W energy transferred, *E*, in joules, J time, *t*, in seconds, s work done, *W*, in joules, J	Define the term power. Recall and apply these equations.	1	Evaluate the benefits and drawbacks of using lower power devices such as compact fluorescent lamps (CFLs). Carry out calculations to determine power, using energy transferred divided by time and work done divided by time. WS 1.2, MS 3b, 3c Recall and apply both of these equations.	Investigating power. Find out how much power students have by getting them to perform simple tasks. Examples could include walking up a flight of stairs, lifting masses up a known height and pulling an object across a floor. For each case the students need to know the work done and the time taken. Obtaining and presenting primary evidence:	Work done: BBC Bitesize – Work and power

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	An energy transfer of 1 joule per second is equal to a power of 1 watt.				Is mechanical power the same as electrical power? Demonstrate measuring the energy transferred to a low voltage motor as it lifts a load. Compare it to the gravitational potential energy gained by the load.	
4.7.2.7 cont.	The power of an electrical device is related to the potential difference across it and the current through it by the equation: power = potential difference × current [*P* = *V I*] power = (current)^2 × resistance	Define power. State the equation that links power, potential difference and current. Calculate the power of an electrical appliance given the potential difference and the current.	1	Why is a 7 W energy efficient light bulb cheaper to run than a 100 W incandescent light bulb? Calculate which fuse rating would be needed in a plug for a given electrical appliance when given the power rating and the potential difference.	Demonstrate a model of the National Grid to show the effect of sending electrical energy at high and low potential differences.	BBC Bitesize – Calculating electrical power Pass My Exams – Electrical Power and Electricity Bill Teachit Science resource (23323) 'Power ratings and calculations'

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	[$P = I^2 R$] power, *P*, in watts, W potential difference, *V*, in volts, V current, *I*, in amperes, A resistance, *R*, in ohms, Ω			Which fuse should you put into a hair drier and why? Conversion to SI units may also be required. Evaluate whether the fuse in a given situation is suitable based on the current drawn by the appliance. WS 1.2, MS 3b, 3c Recall and apply both of these equations.		
4.7.2.8	Everyday electrical appliances are designed to bring about energy transfers. The amount of energy an appliance transfers depends on how long the appliance is switched on for and the power of the appliance.	Describe the energy changes that are taking place in a given electrical appliance – stating which energy transfers are useful and which are wasted. Describe how the amount of energy transferred depends	0.5	What energy changes take place in electrical appliances? WS 1.4 Explain everyday and technological applications of science.	Investigate a number of electrical appliances, either around the lab or well-known devices, eg a TV, to look at the energy transfers that occur within them. Investigate how the amount of energy transferred to an	BBC Bitesize – Energy transfer Teachit Science resource (23331) 'Energy transfers'

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		on the time the appliance is on for and the power of the appliance.			electrical appliance depends on the amount of time that it is on for by connecting the appliance up to a joulemeter.	
4.7.2.8 cont.	Work is done when charge flows in a circuit. The amount of energy transferred can be calculated using the equations: energy transferred = power × time [$E = P\ t$] energy transferred = charge flow × potential difference [$E = Q\ V$] energy transferred, E, in joules, J power, P, in watts, W	Describe how work is done when a charge flows in a circuit. Describe, with examples, the relationship between the power ratings for domestic electrical appliances and the changes in stored energy when they are in use. Calculate the energy transferred by an electrical appliance and rearrange the	1	Discussion questions: • What are the charge carriers in an electric current? • How does a moving charge do work? • What can moving charge do?		BBC Bitesize – Electrical energy calculations Pass My Exams – Electrical Power and Electricity Bill

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	time, *t*, in seconds, s charge flow, *Q*, in coulombs, C potential difference, *V*, in volts, V	equation to find the other two values. Use the equation including rearranging the equation to find any quantity given the other two. Convert units into SI units where required. Use of standard form may also be required as well as understanding the meaning of the different prefixes used in a scientific context.				
4.7.2.9	The National Grid is a system of cables and transformers linking power stations to consumers. Electrical power is transferred from power	Describe how electrical power is transferred from the power stations to the consumers via the National Grid.	1	How does electricity get from the power station to our homes? A large potential difference is dangerous. Why is the electricity sent at a high	Model the National Grid to show how electricity is sent from power stations to consumers. Demonstrate how transformers work and	Video clip YouTube: [AQA GCSE Science and P1 – The National Grid]()

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	stations to consumers using the National Grid. Step-up transformers are used to increase the potential difference from the power station to the transmission cables then step-down transformers are used to decrease, to a much lower value, the potential difference for domestic use.	Students will need to be able to give the types of transformer used and describe how the potential difference in the wires changes at each stage of the process.		potential difference rather than a low p.d.? How do transformers work? What do substations do? Explain how the National Grid system is an efficient way to transfer energy. Link the equation $P = I^2 R$ to the use of high voltage power lines as being the most efficient way of sending electrical energy as increasing the potential difference will reduce the current in the wires. Understand that when the potential difference is doubled the current is halved as and the electrical power remains constant. WS 1.4	where they are placed in the National Grid.	Cyberphysics – National Grid – Electricity Distribution Pass My Exams – Electricity Generation, The National Grid BBC Bitesize Dynamos and transformers BBC Bitesize – Transformers – Higher

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				Explain everyday and technological applications of science.		

4.7.3 Acids and alkalis

Spec ref.	Summary of the specification content	Learning outcomes *What most candidates should be able to do*	Suggested timing (hours)	Opportunities to develop Scientific Communication skills	Opportunities to apply practical and enquiry skills	Self/peer assessment Opportunities and resources *Reference to past questions that indicate success*
4.7.3.1	Acids react with some metals to produce salts and hydrogen. Knowledge of reactions with metals is limited to those of magnesium, zinc and iron with hydrochloric and sulfuric acids. The test for hydrogen uses a burning splint held at the open end of a test tube of the gas.	Recall that acids react with some metals. Write equations predicting products from given reactants. Describe test to identify hydrogen.	1	(HT only) Explain, in terms of gain or loss of electrons, that the reactions of metals with acids are redox reactions (see 4.7.5, Atoms into ions and ions into atoms. (HT only) Identify which species are oxidised and which are reduced in given chemical equations. Write word and balanced symbol equations for these reactions. (HT only) Use the balanced symbol equations to identify which species have been oxidised and which have been reduced. Explain why each species has been oxidised or reduced.	Investigate the reactions of the following metals with sulfuric acid: • magnesium • zinc • iron. Carry out the test for hydrogen collected from the reactions above.	Nuffield class practical – metals and acids RSC AfL Chemistry: Reaction of acids with metals and carbonates

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4.7.3.1 cont.	Acids react with some metal carbonates to produce salts, water and carbon dioxide. The test for carbon dioxide uses an aqueous solution of calcium hydroxide (limewater).	Recall that acids react with metal carbonates. Write equations predicting products from given reactants. Describe test to identify carbon dioxide.	1	Using common reactants, predict the products.	Investigate the reactions between acids and metal carbonates. Write word and balanced symbol equations for these reactions.	Video clips: BBC Bitesize Acids and alkalis BBC Bitesize Neutralisation BBC Bitesize How neutralisation is used in diving apparatus
4.7.3.2	Acids are neutralised by alkalis (eg soluble metal hydroxides) and bases (eg insoluble metal hydroxides and metal oxides) to produce salts and water, and by metal carbonates to produce salts, water and carbon dioxide. The particular salt produced in any reaction between an acid and a base or alkali depends on:	Define the term neutralisation. Predict products from given reactants. Use the formulae of common ions to deduce the formulae of salts.	1	Predict products from given reactants. WS 1.2 Use the formulae of common ions to deduce the formulae of salts.	Investigate the following reactions: • acids + soluble metal hydroxide • acid + insoluble metal hydroxide Write word and balanced symbol equations for these reactions.	Teachit Science resource (22425) 'Naming salts'

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	• the acid used (hydrochloric acid produces chlorides, nitric acid produces nitrates and sulfuric acid produces sulfates) • the positive ions in the base, alkali or carbonate.					
4.7.3.2 cont.	Soluble salts can be made from acids by reacting them with solid insoluble substances such as metals, metal oxides, hydroxides or carbonates. The solid is added to the acid until no more reacts and the excess solid is filtered off to produce a solution of the salt. Salt solutions can be crystallised to produce solid salts.	Define the terms: • soluble • insoluble. Explain what is meant by a soluble salt. Explain why reactants are often used in excess. Suggest suitable purification techniques given information about the substances involved.	1	Extended writing: describe how to make a pure, dry sample of a soluble salt.	Research how to make a pure, dry sample of a soluble salt. For example sodium hydroxide reacting with hydrochloric acid to produce sodium chloride. Write a full description of this method. **Required practical 17:** preparation of a pure, dry sample of a soluble salt from an insoluble	

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					oxide or carbonate, using a Bunsen burner and a water bath or electric heater to evaporate the solution. Chemistry AT 2, 3, 4 and 6	
4.7.3.3	When chemical reactions occur, energy is transferred to or from the surroundings. Energy is conserved in chemical reactions. The total amount of energy in the reaction mixture and its surroundings at the end of a chemical reaction is the same as it was at the start. An exothermic reaction is one that gives out energy. This heats up the reaction mixture. Energy then transfers to the surroundings	Distinguish between exothermic and endothermic reactions on the basis of the temperature change of the surroundings. Evaluate uses and applications of exothermic and endothermic reactions given appropriate information.	1	Research everyday energy changes and industrial energy changes. Suggest how the type of energy change links to the use. WS 1.2 Identify examples of exothermic and endothermic reactions based on the temperature change of the reaction mixture.	Carry out simple experiments that are exothermic or endothermic, such as: • hydrochloric acid and sodium hydroxide • hydrochloric acid and anhydrous sodium carbonate • ethanoic acid and solid ammonium carbonate	Video clips: BBC Bitesize Endothermic and exothermic reactions YouTube: Exothermic and Endothermic Reactions

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	as the reaction mixture then cools. Neutralisation of an acid with an alkali is an example of an exothermic reaction. An endothermic reaction is one that that takes in energy. This cools the reaction mixture. Energy then transfers from the surroundings as the reaction mixture then warms up again. The reaction of citric acid and sodium hydrogen carbonate is an example of an endothermic reaction.				• distilled water and solid ammonium nitrate • hydrochloric acid and magnesium ribbon. Investigate the temperature change when sports injury packs or cooling packs are activated. Ask questions like: which produces the greatest temperature change? **Required practical 18:** Investigate the variables that affect the temperature changes of a series of reactions in solutions, eg acid plus metals, acid plus	

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					carbonates, neutralisations, displacement of metals. Chemistry AT 1, 3, 5 and 6.	
4.7.3.4	Acids produce hydrogen ions (H^+) in aqueous solutions. Aqueous solutions of alkalis contain hydroxide ions (OH^-). The pH scale, from 0 to 14, is a measure of the acidity or alkalinity of a solution and can be measured using universal indicator or a pH probe. A solution with pH 7 is neutral. Aqueous solutions of acids have pH values of less than 7 and aqueous solutions of alkalis have pH values greater than 7.	Recall that acids form hydrogen ions when they dissolve in water and solutions of alkalis contain hydroxide ions. (HT only) Use the formulae of common ions to write balanced ionic equations. Recall that relative acidity and alkalinity are measured by pH. Recognise that aqueous neutralisation reactions can be generalised to	1	Define the following terms: • acid • base • alkali • neutral. Recall the pH numbers for the following solutions: • acidic • alkaline • neutral. Write the symbol equation for the neutralisation of an acid and an alkali. WS 2.3	Measure the pH of a variety of the following solutions: • acidic • alkaline • neutral. Practical: measure the pH change when a strong acid neutralises a strong alkali. This is best done using a data logger and pH probe or digital pH meter. Apparatus and techniques Investigation	Video clips: BBC Bitesize Acidic, alkaline or neutral YouTube: What are Indicators and how do we use them? RSC: pH: basics simulation

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	In neutralisation reactions between an acid and an alkali, hydrogen ions react with hydroxide ions to produce water.	hydrogen ions reacting with hydroxide ions to form water.		Describe the use of universal indicator or a wide range indicator to measure the approximate pH of a solution. WS 3.2 Use the pH scale to identify acidic or alkaline solutions.	of pH changes during neutralisation reactions provides opportunities to cover the measurement of pH (biology AT 1 and chemistry AT 3).	
4.7.3.5	(HT only) A strong acid is completely ionised in aqueous solution. Examples of strong acids are hydrochloric, nitric and sulfuric acids. A weak acid is only partially ionised in aqueous solution. Examples of weak acids are ethanoic, citric and carbonic acids. For a given concentration of aqueous solutions, the	Use and explain the terms dilute and concentrated (amount of substance) and weak and strong (degree of ionisation) in relation to acids. Recall that as hydrogen ion concentration increases by a factor of ten the pH value of a solution decreases by a factor of one.	1	Explain the meaning of the following terms: • dilute • concentrated • weak • strong. Explain why strong acids are completely ionised in aqueous solutions but a weak acid is only partially ionised. Recall examples of strong and weak acids.	Use universal indicator or a pH probe to measure the pH of hydrochloric acid, ethanoic acid, sodium hydroxide and ammonium hydroxide. Be careful to use the same concentration of each. Compare the rate of reaction when magnesium is dipped in hydrochloric acid and	RSC Acid-base solutions simulation

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	stronger an acid, the lower the pH.	Describe neutrality and relative acidity and alkalinity in terms of the effect of the concentration of hydrogen ions on the numerical value of pH (whole numbers only).		Describe neutrality in terms on hydrogen ion concentration. Describe relative acidity in terms of hydrogen ion concentration.	ethanoic acid of the same concentration.	

4.7.4 The rate and extent of chemical change

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4.7.4.1	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: $mean\ rate\ of\ reaction = \frac{quantity\ of\ reactant\ used}{time\ taken}$ or $mean\ rate\ of\ reaction = \frac{quantity\ of\ product\ formed}{time\ taken}$ The units of rate of reaction may be given as g/s, cm^3 /s ((HT only) or mol/s). The rate of a chemical reaction can be determined by measuring:	Describe the effect of changes in temperature, concentration, pressure, and surface area on rate of reaction. Suggest practical methods for determining the rate of a given reaction.	1	Use graphical data to explain each part of the graph, ie: • initially rate is fast • slows down • reaction completes. Extended writing: write instructions to another student how to calculate the mean rate of reaction. Explain what is meant by the units: • g/s • cm^3/s • mol/s. MS 1a, 1c Calculate the mean rate of a reaction from given information about the quantity of a reactant used or the quantity	React $CaCO_3$ with dilute HCl and measure the volume of CO_2 evolved against time. Record the results and plot a graph of results of volume of gas against time. Use the results and graph to determine the mean rate of reaction. A similar reaction can be done with magnesium and hydrochloric acid.	Nuffield practical: Rate of reaction of magnesium with hydrochloric acid

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	• the loss in mass of a reactant's mixture • the volume of gas produced • the time for a solution to become opaque or coloured.			of a product formed and the time taken. MS 4a, 4b, 4c Draw, and interpret, graphs showing the quantity of product formed or quantity of reactant used up against time. MS 4e Draw tangents to the curves on these graphs and use the slope of the tangent as a measure of the rate of reaction. MS 4d, 4e (HT only) Calculate the gradient of a tangent to the curve on these graphs as a measure of rate of reaction at a specific time.		

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4.7.4.2	Breaking up a solid reactant into smaller pieces increases the surface area that can be in contact with any solution with which it reacts. Increasing the ratio of surface area to volume increases the rate of reaction for a given mass of a solid reactant.	Explain the effects on rates of reaction of changes in the size of the pieces of a reacting solid in terms of surface area to volume ratio.	0.5	MS 1c Use ratios, fractions and percentages.		
4.7.4.3	According to collision theory, chemical reactions can occur only when reacting particles collide with each other and with sufficient energy. The minimum amount of energy that particles must have to react is called the activation energy.	Explain the effects on rates of reaction of changes in temperature, concentration and pressure in terms of the frequency and energy of collision between particles.	0.5	Describe collision theory. Use collision theory to explain the change in rate of reaction in terms of particle behaviour for: • concentration • pressure • surface area • temperature • catalyst.	**Required practical 19:** investigation of how changes in concentration affect the rates of reactions by a method involving measuring the volume of a gas produced and a method involving a change in colour or turbidity. This should be an investigation	Video clips: YouTube: Collision theory 1 YouTube: Collision theory 2

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					involving developing a hypothesis. Chemistry AT 1, 3, 5 and 6.	
4.7.4.3 cont.	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. Increasing the temperature increases the frequency of collisions and makes the collisions more energetic, and so increases the rate of reaction.	Explain the effects on rates of reaction of changes in temperature, concentration and pressure in terms of frequency and energy of collision between particles.	0.5	WS 1.2 Predict and explain the effects of changing conditions on the rate of a reaction.		Video clips: BBC Bitesize Collision theory and how to speed up rates of reaction YouTube: Rates of reaction RSC AfL Chemistry: Rate of reaction graphs
4.7.4.4	Chemical reactions can occur only when reacting particles collide with each other and with sufficient	Explain activation energy as the energy	1	Define the term activation energy.	Demo, and where appropriate practically investigate, the reactivity of some	

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	energy. The minimum amount of energy that particles must have to react is called the activation energy. Reaction profiles can be used to show the relative energies of reactants and products, the activation energy and the overall energy change of a reaction.	needed for a reaction to occur. Draw simple reaction profiles (energy level diagrams) for exothermic and endothermic reactions showing the relative energies of reactants and products, the activation energy and the overall energy change, with a curved arrow to show the energy as the reaction proceeds Use reaction profiles to identify reactions as exothermic or endothermic		Draw reaction profiles for exothermic and endothermic. Explain what the diagrams display. WS 3.2, 3.5, MS 4a Use reaction profiles to identify reactions as exothermic or endothermic.	metals with water and acid. Use YouTube clips or let students investigate the reactivity of some other combinations. Use findings to construct a reactivity series. Compare this to the actual reactivity series.	

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4.7.4.5	(HT only) During a chemical reaction: • energy must be supplied to break bonds in the reactants • energy is given out when bonds in the products are formed. The energy needed to break bonds and the energy given out when bonds are formed can be calculated from bond energies. The difference between the sum of the energy needed to break bonds in the reactants and the sum of the energy given out when bonds in the products are formed is the overall energy change of the reaction.	Calculate energy changes in a chemical reaction by considering bond making and bond breaking energies.	1	Calculate the energy transferred in chemical reactions. Extended writing: write instructions to another student how to calculate the energy transferred in a chemical reaction. Explain why a chemical reaction is classed as being exothermic or endothermic in relation to the energy involved in breaking and making bonds. WS 1.2, MS 1a, 4a Calculate the energy transferred in chemical reactions between simple molecules in the gas state using bond energies supplied.	Research common bond energies and use these in calculation for simple reactions.	Video clip YouTube: Introduction to bond energies

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	In an exothermic reaction, the energy given out from forming new bonds is greater than the energy needed to break existing bonds. In an endothermic reaction, the energy needed to break existing bonds is greater than the energy given out from forming new bonds					
4.7.4.6	Catalysts change the rate of chemical reactions but are not used up during the reaction. Different reactions need different catalysts. Knowledge of the names of catalysts other than those specified in the subject content is not required.	Describe the characteristics of catalysts and their effect on rates of reaction. Identify catalysts in reactions. Explain catalytic action in terms of activation energy.	1	Define the term activation energy. Identify advantages of using catalysts in industrial reactions, eg reducing costs. Explain the effect of using a catalyst on the activation energy. WS 3.5 Identify catalysts in reactions from their effect on the rate of	Research different catalysts and their uses in industry. Research catalytic converters.	Video clip YouTube: What are catalysts?

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				reaction and because they are not included in the chemical equation for the reaction.		
4.7.4.7	Enzymes are important as biological catalysts which allow all the reactions in cells to occur. Enzymes are large protein molecules. The shape of an enzyme is vital for its function. Each enzyme has an active site with a unique shape to bind a specific substrate molecule. High temperatures and extremes of pH denature the enzyme, changing the shape of the active site. The 'lock and key' model is a simplified model of enzyme action. Different enzymes work fastest at different temperatures and pH values	Define the terms 'catalyst' and 'enzyme'. Describe the properties of enzymes. Explain why enzymes are specific and are denatured by high temperatures and extremes of pH. Use the lock and key theory and collision theory to explain enzyme action.	2	Recap KS3 work on enzymes. Demo: the action of an inorganic catalyst and catalase, using living and dead tissues, on the breakdown of hydrogen peroxide. Use the observations to lead into the properties of enzymes. Watch a video clip to help to describe the action of catalase. Watch computer simulations to help make notes and explain the properties of enzymes. Make models or cut-outs to demonstrate the shape of the active site of an enzyme and the shape of the substrate(s).	Interpret observations of the action of a catalyst and of catalase from celery, potato, fresh liver and boiled liver on hydrogen peroxide. Explore how the rate of a reaction can be measured by measuring the volume of gas given off in a given time. Calculate the rate using data obtained. Discuss how the equipment could be adapted to investigate the effect of a factor on the rate of the reaction.	Demo: • manganese dioxide • liver, boiled liver, celery, apple or potato • hydrogen peroxide • test tubes or small beakers • goggles. BBC Bitesize: Enzymes and active sites Properties of enzymes Demo: • living tissue

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				Demo: how the rate of the catalase reaction can be measured using a gas syringe or inverted cylinder of water and timer to prepare for the Required practical next lesson. MS 1a, 1c, 1d Carry out rate calculations for chemical reactions and make estimates of simple calculations without using a calculator.	Make predictions and identify variables. **Required practical 20:** investigate the effect of pH on the rate of reaction of amylase enzyme. Students should use a continuous sampling technique to determine the time taken to completely digest a starch solution at a range of pH values. Iodine reagent is to be used to test for starch every 30 seconds. Temperature must be controlled by use of a water bath or electric heater. Biology AT 1, 2, and 5 MS 1a, 1c, 1d	• hydrogen peroxide • flask • delivery tube • gas syringe • cylinder and trough • timer.

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4.7.4.8	In some chemical reactions, the products of the reaction can react to produce the original reactants. Such reactions are called reversible reactions and are represented: $A + B \rightleftharpoons C + D$ The direction of reversible reactions can be changed by changing the conditions. Examples include the effect of changing the temperature on the decomposition of ammonium chloride and of hydrated copper(II) sulfate.	Recall that some reactions may be reversed by altering the reaction conditions.	0.5	Explain what is meant by a reversible reaction. Explain the difference between: $\rightleftharpoons$ reactions and $\rightarrow$ reactions.	Practical: hydrate or dehydrate copper sulfate. Write a balanced equation for the reaction and describe the full process. Heat ammonium chloride in a test tube. Use mineral wool to support a piece of damp pH paper half way up the tube and observe the colour change. Interpret the results (blue then red) in terms of the thermal decomposition of the ammonium chloride into ammonia and hydrogen chloride.	Video clips: BBC Bitesize Reversible reactions YouTube: What are Reversible Reactions?

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4.7.4.9	When a reversible reaction occurs in apparatus which prevents the escape of reactants and products, equilibrium is reached when the forward and reverse reactions occur at exactly the same rate.	Recall that dynamic equilibrium occurs when the rates of forward and reverse reactions are equal.	0.5	Explain the term equilibrium and give suitable examples of when it can occur.	Research examples of equilibrium reactions in industry.	Video clip YouTube: What is Dynamic Equilibrium?
4.7.4.10	(HT only) The relative amounts of all the reactants and products at equilibrium depend on the conditions of the reaction. If a system is at equilibrium and a change is made to any of the conditions, then the system responds to counteract the change. The effects of changing conditions on a system at equilibrium can be predicted	Make qualitative predictions about the effect of changes on systems at equilibrium when given appropriate information.	1	Describe Le Chatelier's principle. Explain the effects on equilibrium of changing conditions using suitable examples. Research the work of Le Chatelier or the life of Fritz Haber. Highlight the moral ambiguity of Haber's work.		Video clips: YouTube: Le Chatelier's Principle Part 1 BBC Bitesize Formation of ammonia using the Haber Process YouTube: What is the Haber Process? RSC: Fritz Haber podcast

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	using Le Chatelier's Principle.					
4.7.4.10 cont.	(HT only) 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 change until equilibrium is reached again. If the concentration of a reactant is increased, more products form until equilibrium is reached again. If the concentration of a product is decreased, more reactants react until equilibrium is reached again.	Interpret appropriate given data to predict the effect of a change in concentration of a reactant or product on given reactions at equilibrium. Suggest appropriate conditions to produce a particular product.	0.5	Use data to predict the effect of concentration on equilibrium. Justify answers. WS 3.5 Interpret appropriate given data to predict the effect of a change in concentration of a reactant or product on given reactions at equilibrium.		BBC Bitesize- Shifting the equilibrium position
4.7.4.10 cont.	(HT only)	Interpret appropriate given data to predict the effect of a change	0.5	Use data to predict the effect of temperature on equilibrium.		Video clip

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	If the temperature of a system at equilibrium is increased: • the relative amount of products at equilibrium increases for an endothermic reaction • the relative amount of products at equilibrium decreases for an exothermic reaction. • If the temperature of a system at equilibrium is decreased: • the relative amount of products at equilibrium decreases for an endothermic reaction • the relative amount of products at equilibrium increases for an exothermic reaction.	in temperature on given reactions at equilibrium. Suggest appropriate conditions to produce a particular product.		WS 1.2 Apply the idea that if a reversible reaction is exothermic in one direction, it is endothermic in the opposite direction.		YouTube: Le Chatelier's Principle Part 2

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4.7.4.10 cont.	(HT only) For gaseous reactions at equilibrium: • an increase in pressure causes the equilibrium position to shift towards the side with the smaller number of molecules, as shown by the symbol equation for that reaction • a decrease in pressure causes the equilibrium position to shift towards the side with the larger number of molecules, as shown by the symbol equation for that reaction.	Interpret appropriate given data to predict the effect of pressure changes on given reactions at equilibrium. Suggest appropriate conditions to produce a particular product.	0.5	Use data to predict the effect of pressure on equilibrium. Justify answers.		

4.7.5 Atoms into ions and ions into atoms

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4.7.5.1	When metals react with other substances the metal atoms form positive ions. Metals can be arranged in order of their reactivity in a reactivity series. The metals potassium, sodium, lithium, calcium, magnesium, zinc, iron and copper can be put in order of their reactivity from their reactions with water and dilute acids. The non-metals hydrogen and carbon are often included in the reactivity series. A more reactive metal can displace a less reactive metal from a compound.	Recall and describe the reactions, if any, of potassium, sodium, lithium, calcium, magnesium, zinc, iron and copper with water or dilute acids, where appropriate, to place these metals in order of reactivity. Explain how the reactivity of metals with water or dilute acids is related to the tendency of the metal to form its positive ion. Deduce an order of reactivity of metals	1	Draw the atomic structure of metals and the ion formed. Use these to describe how the ion has been formed. Make links between the ability to form ions and the reactivity with water and acid. Describe what occurs in a displacement reaction, using suitable examples. Explain why displacement occurs. Compare the year of discovery of a metallic element with its position in the reactivity series. Link discoveries to new technology such as the invention of the battery.	Demo, and where appropriate practically investigate, the reactivity of some of the metals with water and acid. Use YouTube clips or let students investigate the reactivity of the remaining combinations. Use findings to construct a reactivity series. Compare this to the actual reactivity series.	Video clips: BBC Bitesize Reactivity of metals and their uses YouTube: The reactivity series

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	The reactions of metals with water and acids are limited to room temperature and do not include reactions with steam.	based on experimental results.		Recall and describe the reactions, if any, of potassium, sodium, lithium, calcium, magnesium, zinc, iron and copper with water or dilute acids. WS 3.5 Deduce an order of reactivity of metals based on experimental results. WS 1.2 (HT only) Write ionic equations for displacement reactions.		
4.7.5.2	When an ionic compound is melted or dissolved in water, the ions are free to move about within the liquid or solution. These liquids and solutions are able to	Describe electrolysis in terms of the ions present and reactions at the electrodes. Recall that metals (or hydrogen) are formed at the cathode and	1	Explain why solid ionic compounds cannot conduct electricity but ionic compounds can conduct electricity when melted or dissolved in water.	Carry out the electrolysis of solutions following the RSC method.	Electrolysis practical RSC Electrolysis of solutions Video clips:

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	conduct electricity and are called electrolytes. Passing an electric current through electrolytes causes the ions to move to the electrodes. Positively charged ions move to the negative electrode (the cathode), and negatively charged ions move to the positive electrode (the anode). Ions are discharged at the electrodes producing elements. This process is called electrolysis. When a simple ionic compound is electrolysed in the molten state using inert electrodes, the metal is produced at the cathode	non-metals are formed at the anode in electrolysis using inert electrodes.		Define the term electrolyte. Describe how an electric current can pass through an ionic compound. Explain what happens to positive and negative ions during electrolysis and how elements form from their ions. Predict the products of electrolysis of binary ionic compounds in the molten state. WS 1.2 (HT only) Write half equations for the reactions occurring at the electrodes during electrolysis. Students may be required to complete and balance supplied half equations.	Write balanced symbol equations for these reactions. Write half equations for the reactions that occur at each electrode.	BBC Bitesize Electrolysis and electroplating YouTube: GCSE Science Revision Electrolysis of a Solution

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	and the non-metal is produced at the anode.					
4.7.5.3	The ions discharged when an aqueous solution is electrolysed using inert electrodes depend on the relative reactivity of the elements involved. At the negative electrode (cathode), hydrogen is produced if the metal is more reactive than hydrogen. At the positive electrode (anode), oxygen is produced unless the solution contains halide ions when the halogen is produced. This happens because in the aqueous solution water molecules break down	Predict the products of the electrolysis of aqueous solutions containing a single ionic compound.	2	Define the term aqueous. Extended writing: describe how an aqueous solution is electrolysed. Explain why the following atoms could be produced: • hydrogen • oxygen. WS 1.2 (HT only) Write half equations for the reactions occurring at the electrodes during electrolysis. Students may be required to complete and balance supplied half equations.	Electrolyse aqueous copper (II) sulfate following the RSC method. Write balanced half equations for the reactions that occur at both electrodes. Write a full description of this method. **Required practical 21:** investigate what happens when aqueous solutions are electrolysed using inert electrodes. This should be an investigation involving developing a hypothesis.	RSC practical method RSC Electrolysis copper sulfate

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	producing hydrogen ions and hydroxide ions that are discharged.				Chemistry AT 3 and 7	
4.7.5.4	The test for hydrogen uses a burning splint held at the open end of a test tube of the gas. The test for oxygen uses a glowing splint inserted into a test tube of the gas. The test for chlorine uses damp litmus paper put into chlorine gas.	Describe tests to identify oxygen, hydrogen and chlorine.	0.5	Describe the test for hydrogen, oxygen and chlorine to another student. (Links to 4.7.3.1, Reactions of acids.)	Carry out a simple test for hydrogen and oxygen. Small amounts of chlorine can be generated from the electrolysis of brine (either as a demonstration or during a class practical).	Video clip YouTube: Testing for Hydrogen, Oxygen, Carbon Dioxide, Ammonia and Chlorine

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4.7.5.5	(HT only) Oxidation is the loss of electrons and reduction is the gain of electrons. During electrolysis, at the cathode (negative electrode), positively charged ions gain electrons and so the reactions are reductions. At the anode (positive electrode), negatively charged ions lose electrons and so the reactions are oxidations.	Explain reduction and oxidation in terms of gain or loss of electrons. Write ionic equations for displacement reactions. Identify in a given reaction, symbol equation or half equation which species are oxidised and which are reduced.	1	Write balanced symbol equations/half equations for the displacement of metal oxides. Use these to identify which species has been oxidised or reduced. Give reasons for your answers. WS 1.2 Identify, in a given reaction, symbol equation or half equation, which species are oxidised and which are reduced.	Carry out simple displacement reactions. Write ionic equations for these reactions.	YouTube: What are Reduction and Oxidation? BBC Bitesize What is rust?