Multiple choice questioning and whole class feedback

Matthew Hirst

Emmanuel College

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Executive summary

Description of the intervention

Science pupils aged 11–12 used Learning by Questions (LbQ) for 45 minutes each week for 18 weeks. After the majority of pupils completed a question set, teachers used the assessment data provided by LbQ to provide whole-class feedback which was predominantly re-teaching content or explaining the answers for difficult questions.

Pupils completed at least two different question sets from LbQ in each session. Pupils completed a question set and then teachers gave whole-class feedback on the questions that pupils struggled with the most. This process was then repeated with another question set. Pupils were set either questions on what they were currently studying or questions to help them retrieve what had been studied previously. The impact of using this innovation was measured against business as usual in similar science classes.

Description of the school

Emmanuel College is a high-performing secondary school in Gateshead, in the north east of England, with 1,426 pupils on roll. The school has pupils from the age of 11 to 18 years old and has quite a wide and diverse catchment area as it stretches into some parts of Newcastle. The current percentage of pupils who are eligible for free school meals stands at 8.4% which is well below that the national average of 14.1% (January 2019). However, the catchment has changed over the past few years. Of the 168 pupils in the sample 22% were eligible for fee school meals (FSM), 10% had English as an additional language (EAL) and 7% of pupils had special educational needs (SEN).

Summary of evaluation

One hundred and sixty-eight pupils in six classes participated in the evaluation. Half of the classes were randomly allocated to the intervention group and the remaining classes formed the control group. All pupils were given a baseline knowledge assessment (the pre-test) at the beginning of the year on the curriculum which they would study. This knowledge-based assessment was closely mapped against curriculum documentation and was designed to assess pupils' scientific knowledge. All pupils then completed the same knowledge assessment 20 weeks later with added recall questions (the post-test) to measure what they had learnt throughout that time period.

Summary of findings

The effect size for all pupils was extremely positive (+0.94) and for those who were eligible for free schools meals it was even greater (+0.97). Through staff voice there was also a noticeable reduction in staff workload in terms of planning lessons, marking and feedback.

Cost

With the cost of the tablet trolleys at £1,483 per year for three years for an average class size of 28, the intervention cost would be £52.96 per pupil per year. However, if the LbQ application was used on existing computers or tablets the cost would be £21.43 per pupil per year.

Introduction

The problem

Emmanuel College is a high-performing comprehensive school in the north east of England which has been rated as outstanding for the 29 years it has been open. In addition to this, it is a designated Teaching School and the flagship school in a small multi-academy trust of six schools from Doncaster to Northumberland. One of the main challenges that the school faces is improving the outcomes of pupils that are pupil premium (PP) or ever free school meals (FSM). As pupils who are PP or FSM are more likely to be lower prior-attaining than their peers, the innovation was aimed at pupils in lower sets.

Traditionally Emmanuel had a policy of formally marking books every two weeks and leaving formative comments. This took a lot of staff time which could be used for planning better lessons or in-class assessment. In a number of subjects, the follow-up tasks or feedforward tasks are completed to a poor standard so that it doesn't help 'close the gap' in pupil attainment.

Additionally, the school has been approached by Gateshead Council to take more pupils after a local school shut down. We have subsequently needed more teaching classrooms in the school as currently we do not have planning permission to expand. Most computer suites have been removed to solve this problem. The tablets that were lent to us from Learning by Questions (LbQ) were used in the intervention to plug this gap.

The focus of the evaluation was to assess the impact of whole-class feedback on staff workload and the attainment of all pupils, including FSM.

Existing evidence

There is evidence that multiple choice questioning can be used to help both assess pupils' understanding (Christodoulou 2016) and to support pupil retrieval of information (Smith 2012). Multiple choice questions can be used instead of fact recall questions to quickly assess pupils' knowledge of the curriculum (Christodoulou 2016) without losing the learning effect produced through retrieval practice (Little 2013). The aim was to use the multiple choice questions within LbQ during the first two terms of the year to aid retrieval and the revision of material. It was hoped that LbQ would also allow staff to assess progress over time and to teach to the gaps in pupils' knowledge.

Retrieving information in different contexts improves long-term memory and improves pupils' schema (EEF 2019). The work of Roediger et al (2008) describes this phenomenon as the 'testing effort' or 'test induced learning' where pupils recall and retrieve information more readily when they have already been asked to retrieve that knowledge from their long-term memory. This is something that we as a science department have already taken on board as we regularly use knowledge tests at the beginning of lessons to help assess pupils' learning.

Additionally, it is well documented that pupils acting on feedback is one of the most effective ways of improving pupils' performance in the classroom. However, the original research by Hattie (1999) argued that pupils responding to teacher intervention is more important than pupils being given passive feedback. This is backed up by the research of Fletcher-Wood (2018) and Wiliam (2013) who argue that assessment can be the strong bridge between teaching and learning. We were keen to measure the effect whole-class feedback can have on science attainment at Key Stage 3.

Research questions

‘What impact does using Learning By Questions followed by whole class feedback delivered for 45 minutes each week for 18 weeks have on the attainment of Year 7 pupils in science knowledge when compared with business as usual?’

‘Is there a difference in the impact of Learning by Questions on the attainment of pupils between those who are eligible for free school meals and those who are not?’

Method

Sample

Emmanuel College is a high-performing secondary school in Gateshead, in the north east of England, with 1,426 pupils on roll. It has been graded outstanding in every one of its inspections since the school was founded in 1991. The school has pupils from the age of 11 to 18 years old and has quite a wide and diverse catchment area as it stretches into some parts of Newcastle. The current percentage of pupils who are eligible for free schools meals (FSM) stands at 8.4% which is well below the national average of 14.1% (Department of Education, 2019).

At the beginning of Key Stage 3 pupils have a varied starting point due to their different experiences of science at primary schools. Therefore the intervention was targeted to help improve the scientific knowledge of pupils at the start of their journey at Emmanuel College. There are 240 pupils in Year 7 and in science they are put into nine different sets using their prior attainment at Key Stage 2 and a cognitive assessment test. The intervention and the control groups were chosen from the lowest prior-attainment set pairings which in total accounts to 168 pupils. The reason why lower and middle prior-attaining pupils were chosen was because they are less likely to make required progress than their higher prior-attaining peers. Of the 168 pupils who took part in the evaluation 39 (23%) pupils were eligible for free school meals and 18 had English as an additional language (EAL) (10%). Of the sample 89 (53%) pupils were male and 79 (47%) pupils were female, again reflecting a national trend that lower prior-attaining pupils are more likely to be male. Out of the sample, 11 pupils (7%) had some form of special educational needs (SEN).

Assignment of conditions

I decided to pair intervention and control groups in order of prior attainment so that the sets would be as comparable as possible. Sets 3, 6 and 8 were placed in the intervention group at random from each of the pairings and sets 4, 5 and 7 were placed in the control group. The staff members who were teaching the intervention groups and those teaching the control groups were all experienced members of staff with more than five years of teaching, apart from the teacher of set 5 who was a newly qualified teacher.

When pupils took the pre-test, attainment was comparable in the sets that were matched up. On average, paired classes were between one and two marks away from each other with a large drop in the lowest prior-attaining set. The pre-test data can be seen below.

TABLE 1: PRE-TEST AVERAGE RAW SCORES

	Intervention	Average raw score	Control group	Average raw score
Pair 1	Set 3	25.8	Set 4	24.7
Pair 2	Set 6	21.4	Set 5	23.4
Pair 3	Set 8	17.1	Set 7	20.2

Innovation

Due to the nature of the timetable and the constraints of the curriculum, we decided to use a single lesson each week to focus on using LbQ, which accounted for 20% of the curriculum time. The remaining 80% of the time was used to cover the curriculum content for Year 7. It was

decided that the intervention lessons would have a formulaic approach across the intervention classes. A copy of the curriculum timeline can be seen below.

TABLE 2: CURRICULUM TIMELINES

		Year 7		
W/C		Set		
		Sets 1-3	Sets 4-6	Sets 7-9
02/09/2019	Week 1	Induction: Lab safety & general introduction		
09/09/2019	Week 2	1B	1C	1P
16/09/2019	Week 3			
23/09/2019	Week 4			
30/09/2019	Week 5			
07/10/2019	Week 6			
14/10/2019	Week 7			
21/10/2019	Half term			
28/10/2019	Week 8	1P	1B	1C
04/11/2019	Week 9			
11/11/2019	Week 10			
18/11/2019	Week 11			
25/11/2019	Week 12			
02/12/2019	Week 13			
09/12/2019	Week 14	1C	1P	1B
16/12/2019	Week 15			
23/12/2019	Christmas			
30/12/2019				
06/01/2020	Week 16			
13/01/2020	Week 17			
20/01/2020	Week 18			
27/01/2020	Week 19			

The content for each of the sections are here:

	Unit Title	Old spec references
Year 7	1C Matter 1	7G - The particle model 7E - Mixtures and separations
	2C Matter 2	7H - Atoms, elements & molecules 8F - The periodic table

	Unit Title	Old spec references
Year 7	1B Organisms 1	7A - Cells,Tissues,Organs,Systems () 7B - Reproduction in animals
	2B Organisms 2	7C - Muscles & Bones () 8A - Breathing and respiration Nutrition and digestion
Year 7	1P Energy and Electricity	7I - Energy () 7J - Current Electrity () New - Heat transfers
	2P Forces	7K - Forces () 8J - Fluids

As a department we have written a ‘knowledge-led’ curriculum document which covers the knowledge that we want pupils to cover in the units C1, B1 and P1. These are based around the Department of Education’s programme of study for Key Stage 3, Best Evidence Science Teaching (University of York Science Education Group) and resources produced in house. The curriculum document consists of knowledge statements that pupils will learn and skills that pupils must be able to do with that knowledge. Copies of the knowledge curriculum documents for each unit of study can be seen in Appendix 1.

Pupils completed two different question sets from LbQ during a 45-minute lesson for 18 weeks. Pupils completed the first question set and then teachers gave whole-class feedback on the questions that pupils struggled with the most. This process was then repeated with another question set. Pupils were set either questions around what they were currently studying or questions to help them revise what had been studied previously.

Lesson format

Timing in minutes	Activity
0–5	Pupils collect the tablets, log into the Wi-Fi and log into Learning by Questions using the code on the board.
5–20	Pupils complete the first Learning by Questions set on either the unit they were covering or a previous unit
20–25	The teacher gives whole-class feedback to the class by looking at common misconceptions and teaching to bridge the gap
25–40	Pupils complete a different set of questions
40–45	Again the teacher gives whole-class feedback and challenges pupils’ misconceptions
45–50	Pack up and teacher to supervise the tablets being placed in the trolley

During the first half-day inset we decided on this lesson structure. Also it was decided to give the teacher the autonomy to choose the question set for their own class depending on where they were in the curriculum and the deliberate practice they wished to set.

The pupils in the control group experienced the normal lesson structure that has been used previously. Both the intervention and control group pupils completed a number of lessons in a unit and then completed a summative assessment based on what they were taught. Pupils were given feedback on this summative assessment.

Innovation training and support

The three staff members who would be delivering the intervention were trained for a half-day with a representative from LbQ. During this time staff members were taught how to find appropriate question sets, how to access the LbQ website, and what the feedback interface was like and were able to practise using the application with each other.

After the first half-day training, the intervention team went away and mapped out question sets that matched the curriculum and shared them with one another. During a second inset, the intervention team discussed how the question sets could be used in a classroom setting and decided when these would be used in the week.

The intervention team spoke regularly about the project throughout the 18 week project. They discussed how they had used the LbQ sets in their lessons at least once a month and shared best practice in how to give whole-class feedback. Lastly, the intervention team had a debrief on how they felt the project had gone and the effects that it had made on their own practice during a final meeting.

The rationale for the intervention was shared with the teachers who were part of the control group and the reason for the pre- and post-tests was explained to staff. Staff were asked to facilitate the pre- and post-tests during a single lesson of science during the week. Details of the LbQ application and the mechanic used to give whole-class feedback were not shared with the teachers in the control group.

Outcome measures

As the dependent variable of the intervention was the scientific knowledge of pupils, progress was measured using a large multiple choice question paper before the intervention and an adapted version after the intervention. In this paper, questions were taken from the Exploring Science Documentation and matched against the curriculum knowledge document that we have produced.

Both assessments were written before the intervention lead had used any of the LbQ sets to reduce bias. In the pre-test the maximum score was 48 with 16 marks awarded for each unit of study and in the post-test the maximum score was 66 with 22 marks awarded for each unit of study. The post-test included the same set of multiple choice questions as the pre-test with six additional fact recall questions included in each section. Multiple choice questions were chosen due their ability to test a broad range of knowledge in a short time and to improve the reliability of the marking. In the post-test the addition of recall questions of key definitions increased the rigour of the assessment and helped to test a large amount of content. The pre-test can be seen in Appendix 2 and the post-test in Appendix 3.

The assessments were given to pupils by their classroom teacher during a single science lesson and all pupils completed the assessment at the same time under exam conditions. No scribes or readers were administered during the assessment. The pre-tests were marked by a teacher from a different department who had no bias towards the project.

Although the original plan for the post-test was for it also to be marked by an independent assessor, due to COVID-19 and the disruption that caused, these were marked by the innovation lead. Those pupils who moved sets during the intervention or were unable to complete both assessments were removed from the data sample; this reduced the sample size from 168 to 145.

Process evaluation

As the intervention sessions were carried out on the same day and the same time it was not possible for lesson observations to take place. Instead, the intervention team had a discussion every four weeks on how the intervention was going and to iron out any problems. This also allowed staff to share what they had learnt and how they had overcome some problems. For example, due to some technical problems one intervention class decided to no longer use the tablets that were provided and had decided to book one of the few computer rooms to carry out the intervention session. As this didn’t change the mechanics of the lesson it was allowed to go

ahead. Lastly, the evaluation leader met with the intervention teachers at least once a week to help solve any issues with the tablets and to ensure that each class was completing 45 minutes of questions each week.

There were a few problems with the WiFi in college which meant that the other two classes had problems with accessing LbQ. This happened for two of the 18 weeks of the projects. Due to the school's firewall, there were on-going problems connecting the tablets to the WiFi and IT support were asked to come and help pupils connect on numerous occasions. Sometimes when this happened it meant that pupils had to work in pairs on the application instead of having their own individual tablet.

There were plans to collect pupil voice data on pupils' perceptions of science lessons and to see if the learning by questions session where mentioned by the intervention group on the reasons why they enjoyed science. There was also due to be a staff voice questionnaire on how well staff believed they knew their pupils. Unfortunately, due to the COVID-19 pandemic and school closures these were not carried out.

Data analysis

To analyse the impact of LbQ, we looked at the average progress of pupils in the intervention and control group between the pre-test and the post-test. We calculated an effect size comparing the average progress of pupils in the intervention group with those in the control group. We also calculated effect sizes comparing the progress of FSM pupils in the intervention and control groups, and comparing progress of non-FSM pupils in the intervention and control groups.

Additionally, we calculated effect sizes based on progress for boys and for girls. We decided to do this because boys are likely to make less progress than girls in the north east of England. This has been widely measured and publicised by the Department for Education. We did not initially plan to carry out this analysis, so these results should be interpreted with caution.

Cost

The cost of the intervention itself was minimal due to LbQ loaning the tablets for the project. If this was not covered the cost of the tablet trolleys at £1,483 per year for three years for an average class size of 28 the intervention cost would be £52.96 per pupil per year. However, if the LbQ application was used on existing computers or tablets the cost per pupil per year would be £21.43.

The main cost for the evaluation itself was staff time. The marking of the pre-assessment and the post-assessment cost £191.76 at a rate of £15.98 per set. The two half-day insets, one for the project set-up and the second to share the project findings, was £3103.02 using each member of staff's daily rate.

It took the intervention lead four days in total to plan, evaluate and write up the intervention at a total cost of £794.80 at £198.70 per day.

Results

Outcomes finding

Table 3: Effect size of the intervention between different groups

Intervention	Control	Total sample size	Effect size
Whole cohort (N=67)	Whole cohort (N=77)	144	+0.94
FSM (N=13)	FSM (N=15)	28	+0.98
Non-FSM (N=54)	Non-FSM (N=62)	116	+0.94
Male (N=32)	Male (N=43)	75	+1.04
Female (N=35)	Female (N=34)	69	+0.88

The results for the individual sub-groups are as follows (all test scores reported to one decimal place):

Table 4: Whole cohort

	Average pre-test score (max score 48)	Average post-test score (max score 66)	Average progress	Effect size
Intervention group (n=67)	22.0	38.3	+16.4	+0.94
Control group (n=77)	23.0	33.2	+10.2	

Table 5: Free school meals (FSM)

	Average pre-test score (max score 48)	Average post-test score (max score 66)	Average progress	Effect size
Intervention group (n=13)	21.7	37.2	+15.5	+0.98
Control group (n=15)	22.7	33	+10.3	

Table 6: Non-FSM

	Average pre-test score (max score 48)	Average post-test score (max score 66)	Average progress	Effect size
Intervention group (n=54)	22	38.6	+16.6	+0.94
Control group (n=62)	22.9	33.3	+10.3	

TABLE 7: MALE

	Average pre-test score (max score 48)	Average post-test score (max score 66)	Average progress	Effect size
Intervention group (n=32)	20.8	38.3	+17.5	+1.04
Control group (n=43)	22.2	32.9	+10.7	

TABLE 8: FEMALE

	Average pre-test score (max score 48)	Average post-test score (max score 66)	Average progress	Effect size
Intervention group (n=35)	23	38.3	+15.4	+0.88
Control group (n=34)	23.8	33.6	+9.8	

As can be seen the results were overwhelmingly positive in all of the sub groups that were looked at. The most pleasant of these effect sizes shows the impact on pupils who are eligible for free school meals, a group who, under normal circumstances, are less likely to make good progress than their peers. Furthermore, the intervention also had a much larger effect on boys than girls, a demographic that has struggled to match the progress of their peers nationally over many years.

Process evaluation findings

A key theme that came from the small-group discussions with the intervention staff was both the improvement of pupil engagement during the intervention sessions and pupils' independence. It was noticed that across all intervention groups there was a clear willingness to improve and to only ask for help when they were truly stuck on a question. Furthermore, staff noticed a difference in their workload as the planning of the sessions was quick and easy and there was no marking involved.

There was also an impact on classes outside the intervention group. All of the intervention teachers used the application for pupils outside the sample. For example, one staff member decided to take what they had been doing with their class and use the same process with their Year 8 pupils. Another staff member used the application for assessing the knowledge with a lower prior-attaining Year 10 physics GCSE class. Therefore, it is not unreasonable to suggest a side-effect of the innovation has been a shift in teacher's behaviour as it has changed their classroom practice. The largest criticism of the intervention was not the session themselves but the IT facilities within the college itself.

Discussion

Interpretation of findings

It is pleasant to see that the intervention has been positive across the sub groups that were chosen, however the extent to which this is true is surprising. The ability to free teachers up to give formative feedback to pupils on an individual level whilst they were completing the question set allowed staff to get to know their pupils better. Using whole-class feedback as a targeted intervention allowed staff to recognise and address misconceptions quickly and efficiently during the intervention session. This undoubtedly had an effect on how teachers taught their classes during their normal science lessons outside the intervention sessions.

The ability to test large sections of the curriculum at one time for retrieval practice is also likely to have played its part. Using question sets that had either been used previously or to help retrieve knowledge from previous units has probably allowed pupils to retain key knowledge better than their peers. This asks serious questions of our current curriculum structure and how it supports pupils' long term memory of what has been taught.

However, I do think that change in teacher behaviour is the most positive outcome from the intervention. The fact that each of the intervention teachers had chosen to use the Learning by Questions (LbQ) application with other classes is a ringing endorsement of what was being carried out. The wider impact on how teacher behaviours have adapted to the intervention is intriguing and exciting. If the department can build upon the skills that have been learnt then it could help pupils in the future.

Limitations

The largest challenge for carrying out the intervention was the accessibility of the IT support within college and the problems associated with the WiFi. This had a significant impact on at least two sessions and was a constant problem during the administration of the tablets. It meant that at times pupils had to share tablets or had long periods of time when they were not working. This was increasingly frustrating near the end of the project when it had become commonplace.

There are also limitations to the assessment that was used. Although it covered a large amount of the scientific knowledge there was no assessment of the Working Scientifically skills that pupils need to master to be a good scientist. Also, it could be argued that due to the nature of the intervention itself intervention pupils had become 'test savvy' which may have inflated their grade. Additionally although the assessment was set up to reduce the risk of the marker being biased, due to restrictions due to COVID-19 and other outside influences, the post-test was not marked by an unbiased assessor. Another limitation of the evaluation was the small sample size especially pupils eligible for free school meals (FSM).

Implications for further evaluation

It would be beneficial to scale up the evaluation to see if LbQ could improve the outcomes of pupils both in Year 7 and 8 using a similar format that was used this year. In order to measure the long-term effect on pupil learning, it would be good to compare pupils' results with a third assessment later in the year to see if there has been a long-term effect on learning rather than test performance. Additionally, the larger assessment could take a slightly different format other than multiple choice questions to test wider scientific skills. The sample group could also be increased by being used in more than one setting. As the Teaching School is in an Alliance the project could be scaled up to see if the same educational gains can be made in our partner schools.

The LbQ assessment tool would be a great application to evaluate in both maths and English. The LbQ innovation projects carried out so far by schools have been predominantly in science. As numeracy and literacy are key skills that allow pupils to access other parts of the curriculum it might be that the impact can be felt over a larger range of subjects. The intervention lead could share his expertise with other departments to help set up their own evaluation.

With the problems that have arisen due to the prolonged school closure during the COVID-19 pandemic, LbQ could be used as a tool to help assess pupils' understanding of what has been taught and to plan better in-class intervention for pupils using the data that is produced. As all pupils in Key Stage 4 are going to be given laptops as part of our school improvement plan, it would be easy to administer during lesson time in the future.

Conclusions

The LbQ application is a great formative assessment tool that, when used correctly, has been found to help support pupils' learning, allow teachers to better know their pupils as learners and to reduce the planning and marking workload. It is good to see that it can be used in a way that can make a positive impact on all pupils' learning but most importantly on those pupils who are generally less likely to make the same progress as their peers.

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Appendix 1

Curriculum knowledge documentation

<table>
<tr><th colspan="3">Year 7</th></tr>
<tr><td colspan="3">Autumn term</td></tr>
<tr><th colspan="3">1B – Organisms 1</th></tr>
<tr><td>Knowledge</td><td><u>Cells</u>
Multicellular organisms are composed of cells which are organised into tissues, organs and systems to carry out life processes.
There are many types of cell. Each has a different structure or feature so it can do a specific job.
<u>Human Reproduction</u>
The menstrual cycle prepares the female for pregnancy and stops if the egg is fertilised by a sperm.
The developing foetus relies on the mother to provide it with oxygen and nutrients; to remove waste and protect it against harmful substances.

Skill
Use a light microscope to observe and draw cells.

Facts
Both plant and animal cells have a cell membrane, nucleus, cytoplasm and mitochondria.
Plant cells also have a cell wall, chloroplasts and usually a permanent vacuole.
The menstrual cycle lasts approximately 28 days.
If an egg is fertilised it settles into the uterus lining.</td><td>Pupils will apply the knowledge by;

Explaining why multi-cellular organisms need organ systems to keep their cells alive.
Suggesting what kind of tissue or organism a cell is part of, based on its features.
Explaining how to use a microscope to identify and compare different types of cells.
Explaining how uni-cellular organisms are adapted to carry out functions that in multicellular organisms are done by different types of cell.
Explaining whether substances are passed from the mother to the foetus or not.
Using a diagram to show stages in development of a foetus from the production of sex cells to birth.
Describing causes of low fertility in male and female reproductive systems.
Identifying key events on a diagram of the menstrual cycle.

<u>Practical skills</u>

Use a light microscope to observe and draw cells.
Work with microscopy images to understand the differences between specialised cells.</td></tr>
<tr><td>Vocabulary</td><td colspan="2"><u>Cells</u>
Cell: The unit of a living organism, contains parts to carry out life processes.
Uni-cellular: Living things made up of one cell.
Multi-cellular: Living things made up of many types of cell.
Tissue: Group of cells of one type.
Organ: Group of different tissues working together to carry out a job.
Diffusion: One way for substances to move into and out of cells.
Structural adaptations: Special features to help a cell carry out its functions.
Cell membrane: Surrounds the cell and controls movement of substances in and out.
Nucleus: Contains genetic material (DNA) which controls the cell's activities.
Vacuole: Area in a cell that contains liquid, and can be used by plants to keep the cell rigid and store substances.</td></tr>
</table>

	Mitochondria: Part of the cell where energy is released from food molecules. Cell wall: Strengthens the cell. In plant cells it is made of cellulose. Chloroplast: Absorbs light energy so the plant can make food. Cytoplasm: Jelly-like substance where most chemical processes happen. Immune system: Protects the body against infections. Reproductive system: Produces sperm and eggs, and is where the foetus develops. Digestive system: Breaks down and then absorbs food molecules. Circulatory system: Transports substances around the body. Respiratory system: Replaces oxygen and removes carbon dioxide from blood. Muscular skeletal system: Muscles and bones working together to cause movement and support the body. **Human Reproduction** Gamete: The male gamete (sex cell) in animals is a sperm, the female an egg. Fertilisation: Joining of a nucleus from a male and female sex cell. Ovary: Organ which contains eggs. Testicle: Organ where sperm are produced. Oviduct, or fallopian tube: Carries an egg from the ovary to the uterus and is where fertilisation occurs. Uterus, or womb: Where a baby develops in a pregnant woman. Ovulation: Release of an egg cell during the menstrual cycle, which may be met by a sperm. Menstruation: Loss of the lining of the uterus during the menstrual cycle Reproductive system: All the male and female organs involved in reproduction. Penis: Organ which carries sperm out of the male's body. Vagina: Where the penis enters the female's body and sperm is received. Foetus: The developing baby during pregnancy. Gestation: Process where the baby develops during pregnancy. Placenta: Organ that provides the foetus with oxygen and nutrients and removes waste substances. Amniotic fluid: Liquid that surrounds and protects the foetus. Umbilical cord: Connects the foetus to the placenta.
Assessment	1B End of Unit test. 45 marks (mainly 1/2 mark questions on recall of knowledge)

Year 7		
Autumn term		
1C - Matter		
Knowledge	Properties of solids, liquids and gases can be described in terms of particles in motion but with differences in the arrangement and movement of these same particles: closely spaced and vibrating (solid), in random motion but in contact (liquid), or in random motion and widely spaced (gas). Observations where substances change temperature or state can be described in terms of particles gaining or losing energy. A substance is a solid below its melting point, a liquid above it, and a gas above its boiling point.	Pupils will **apply** the knowledge by; Explain unfamiliar observations about gas pressure in terms of particles. Explain the properties of solids, liquids and gases based on the arrangement and movement of their particles.

	A pure substance consists of only one type of element or compound, and has a fixed melting and boiling point. Mixtures may be separated due to differences in their physical properties. The method chosen to separate a mixture depends on which physical properties of the individual substances are different.	Explain changes in states in terms of changes to the energy of particles. Draw before and after diagrams of particles to explain observations about changes of state, gas pressure and diffusion. Explain how substances dissolve using the particle model. Use the solubility curve of a solute to explain observations about solutions. Use evidence from chromatography to identify unknown substances in mixtures. Choose the most suitable technique to separate out a mixture of substances. Explain how substances dissolve using the particle model. Use the solubility curve of a solute to explain observations about solutions. Use evidence from chromatography to identify unknown substances in mixtures. Choose the most suitable technique to separate out a mixture of substances. **<u>Practical skills</u>** Use a light microscope to observe and draw cells.
Vocabulary	Particle: A very tiny object such as an atom or molecule, too small to be seen with a microscope. Particle Model: A way to think about how substances behave in terms of small, moving particles. Diffusion: the process by which particles in liquids or gases spread out through random movement from a region where there are many particles to one where there are fewer. Gas pressure: Caused by collisions of particles with the walls of a container. Density: How much matter there is in a particular volume, or how close the particles are. Evaporate: Change from liquid to gas at the surface of a liquid, at any temperature. Boil: Change from liquid to a gas of all the liquid when the temperature reaches boiling point.	

	Condense: Change of state from gas to liquid when the temperature drops to the boiling point. Melt: Change from solid to liquid when the temperature rises to the melting point. Freeze: Change from liquid to a solid when the temperature drops to the melting point. Sublime: Change from a solid directly into a gas. Solvent: A substance, normally a liquid, that dissolves another substance. Solute: A substance that can dissolve in a liquid. Dissolve: When a solute mixes completely with a solvent. Solution: Mixture formed when a solvent dissolves a solute. Soluble: (insoluble) Property of a substance that will (will not) dissolve in a liquid. Solubility: Maximum mass of solute that dissolves in a certain volume of solvent. Pure substance: Single type of material with nothing mixed in. Mixture: Two or more pure substances mixed together, whose properties are different to the individual substances. Filtration: Separating substances using a filter to produce a filtrate (solution) and residue. Distillation: Separating substances by boiling and condensing liquids. Evaporation: A way to separate a solid dissolved in a liquid by the liquid turning into a gas. Chromatography: Used to separate different coloured substances.
Assessment	1C End of Unit test. ~45 marks (mainly 1/2 mark questions on recall of knowledge)

Year 7		
Spring term		
1P – Energy and electricity		
Knowledge	We can describe how jobs get done using an energy model where energy is transferred from one store at the start to another at the end. When energy is transferred, the total is conserved, but some energy is dissipated, reducing the useful energy. Food labels list the energy content of food in kilojoules (kJ). We pay for our domestic electricity usage based on the amount of energy transferred. Electricity is generated by a combination of resources which each have advantages and disadvantages. Calculate the cost of home energy usage, using the formula: cost = power (kW) x time (hours) x price (per kWh). Current is a movement of electrons and is the same everywhere in a series circuit. Current divides between loops in a parallel circuit, combines when loops meet, lights up bulbs and makes components work. Two similarly charged objects repel, two differently charged objects attract.	Pupils will **apply** the knowledge by; Describe how the energy of an object depends on its speed, temperature, height or whether it is stretched or compressed. Show how energy is transferred between energy stores in a range of real-life examples. Calculate the useful energy and the amount dissipated, given values of input and output energy. Explain how energy is dissipated in a range of situations. Compare the amounts of energy transferred by different foods and activities. Compare the energy usage and cost of running different home devices.

		Explain the advantages and disadvantages of different energy resources. Represent the energy transfers from a renewable or non-renewable resource to an electrical device in the home. Describe how current changes in series and parallel circuits when components are changed. Describe what happens when charged objects are placed near to each other or touching. **<u>Practical skills</u>** Turn circuit diagrams into real series and parallel circuits, and vice versa.
Vocabulary	Thermal energy store: Filled when an object is warmed up. Chemical energy store: Emptied during chemical reactions when energy is transferred to surroundings. Kinetic energy store: Filled when an object speeds up. Gravitational potential energy store: Filled when an object is raised. Elastic energy store: Filled when a material is stretched or compressed. Dissipated: Become spread out wastefully. Power: How quickly energy is transferred by a device (watts). Energy resource: Something with stored energy that can be released in a useful way. Non-renewable: An energy resource that cannot be replaced and will be used up. Renewable: An energy resource that can be replaced and will not run out. Examples are solar, wind, waves, geothermal and biomass. Fossil fuels: Non-renewable energy resources formed from the remains of ancient plants or animals. Examples are coal, crude oil and natural gas. Negatively charged: An object that has gained electrons as a result of the charging process. Positively charged: An object that has lost electrons as a result of the charging process. Electrons: Tiny particles which are part of atoms and carry a negative charge. Charged up: When materials are rubbed together, electrons move from one surface to the other. Electrostatic force: Non-contact force between two charged objects. Current: Flow of electric charge, in amperes (A). In series: If components in a circuit are on the same loop. In parallel: If some components are on separate loops.	
Assessment	1P End of Unit test. 45 marks (mainly 1/2 mark questions on recall of knowledge)	

Appendix 2

Pre-innovation assessment

Learning by Questions – content pre-assessment

Name: _____

Set: _____

Advice to candidates
You should take **15 minutes for each** of the three different sections.

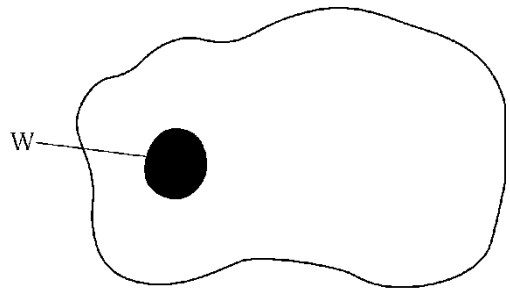
Read all the options before committing to an answer.

Complete all the questions by either circling the answer or writing the letter of the answer next to the question.

If you wish to change an answer simply place a line through the circle and write the letter instead.

Biology content

1. On this drawing of an animal cell, what is the part labelled ‘W’?

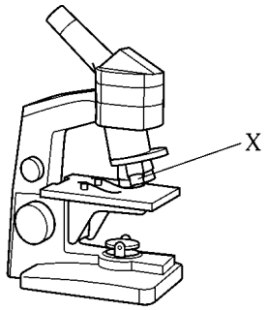


A	cell membrane	**B**	chloroplast
C	nucleus	**D**	Vacuole

2. On the drawing above, what does part ‘W’ do?

A	make energy	**B**	make food
C	control the cell	**D**	acts as the brain

3. On the drawing of a microscope, what is the name of the part labelled ‘X’?



A stage **B** focusing wheel

C objective lens **D** base

4. A microscope has a ×5 eyepiece lens and a ×10 objective lens. The total magnification is:

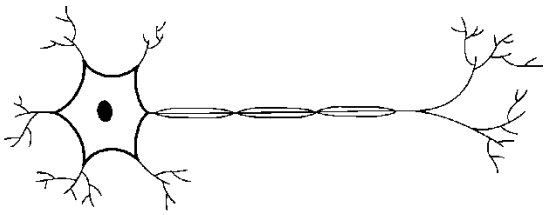
A ×5

B ×10

C ×15

D ×50

5. What sort of cell is this?



A muscle cell

B root hair cell

C nerve cell

6. A **tissue** is:

A a collection of organs helping each other

B another name for an organ

C a group of cells which are the same, all doing the same job

D a group of cells which are all different, all doing different jobs

7. An **organ** is:

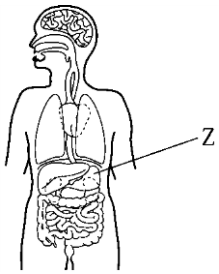
A a group of cells doing different jobs

B a group of tissues helping each other to do a very important job

C a group of cells which are all the same, all doing the same job

D another name for a body

8. In the picture, what is part 'Z'?



A stomach

B hand

C kidney

D lung

9. An organ system is:

A a collection of organs working together to do an important job

B a collection of tissues that do the same job

C a collection of organs that help us breathe

D a way of counting the number of organs in the body

10. Some of the organs in the digestive system are:

A gullet, stomach and ears

B gullet, intestines and lungs

C gullet, intestines and stomach

D kidneys, intestines and heart

11. The sex cells produced in humans are called:

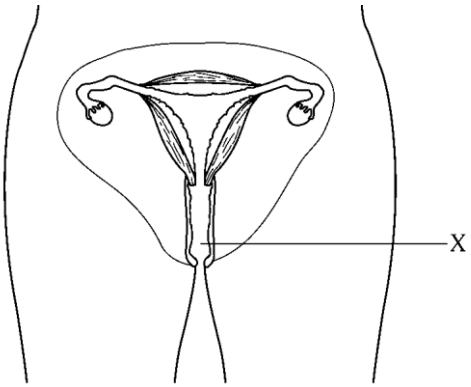
A ovaries and testes

B vagina and penis

C uterus and scrotum

D sperm and egg

12. What is the part labelled ‘X’ in the diagram?



A bladder

B cervix

C uterus

D vagina

13. In males, the scrotum:

A makes semen

B holds the uterus

C holds the testes

D holds the penis in place

14. The loss of blood and the uterus lining in the menstrual cycle is called:

A menstruation

B ovulation

C fertilisation

D urination

15. Fertilisation occurs in:

A an ovary

B a fallopian tube

C the scrotum

D the penis

16. A baby develops inside the:

A vagina

B fallopian tube

C uterus

D ovary

Chemistry content

1. A mixture is:

A just one substance, like pure salt
B two or more things mixed together, like nuts and raisins
C two things joined together, like flour and sugar in a baked cake
D a lot of the same thing put together

2. When something dissolves in water:

A it splits up and disappears into the water
B it sinks to the bottom of the water
C it rises to the top of the water
D it turns the water a milky colour

3. Filtering cannot be used to separate:

A sand from a mixture of sand and water
B sugar from sugar solution
C tea leaves from a pot of tea
D leaves from a mixture of leaves and pond water

4. A solid dissolved in water can be obtained by:

A evaporating the liquid
B using a sieve
C using a filter
D freezing the liquid

5. Which sentence is not true?

A rock salt is a mixture of rock and salt
B rock salt can be used to make pure salt to put on food
C you can get salt from rock salt using a sieve
D you can get salt from rock salt by dissolving, filtering and evaporating.

6. Pure water is:

A water which is clean enough to drink
B water which runs off the hills
C rain
D water with nothing dissolved in it

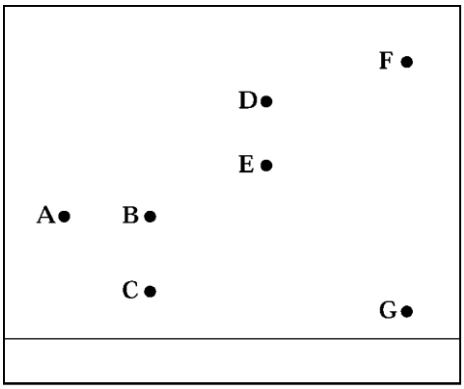
7. Pure water can be made from inky water by:

A filtering it
B evaporating it
C distilling it
D adding more water to it

8. The two steps in distillation are:

A filtering followed by evaporation
B evaporation followed by condensation
C condensation followed by filtering
D filtering followed by condensation

9. The diagram shows a chromatogram. Which two chemicals are the same?



A A and B
B C and B
C D and F
D A and G

10. Everything is made up of:

A particles which are arranged differently in solids, liquids and gases
B particles which are arranged in the same way in solids, liquids and gases
C water particles
D nothing

11. A solid, like rock, has a:

A shape which is easy to change but its volume is fixed
B shape which is fixed but it can change its volume
C shape and a volume which are both easy to change
D shape and volume which are both fixed

12. In a solid:

A the particles are very close together
B the particles are as far apart as possible
C the particles are quite close together
D there are no particles

13. All liquids:

A have a fixed volume and take the shape of their container
B have a fixed volume and a fixed shape
C will spread out until their volume has doubled
D can change their volume but not their shape

14. In a liquid:

A the particles are very close together
B the particles are as far apart as possible
C the particles are quite close together
D there are no particles

15. Gases:

A spread out until they fill the space around them
B do not spread out
C cannot be poured
D keep their shape

16. In a gas:

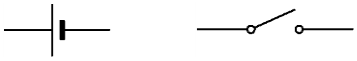
A the particles are held tightly in place by bonds
B there are no particles
C the particles are free to move anywhere
D the strong bonds let the particles move past each other

Physics content

1. Which of these statements is true?

A Plastic is a conductor because it lets electricity flow through it.
B Plastic is an insulator because it lets electricity flow through it.
C Metals are conductors because they let electricity flow through them.
D Metals are insulators because they let electricity flow through them.

2. What do these symbols show?



A a cell and a bulb
B a cell and a switch
C a bulb and a switch
D a switch and a motor

3. Which instrument would you use to measure current?

A an ammeter
B a cell
C a motor
D a voltmeter

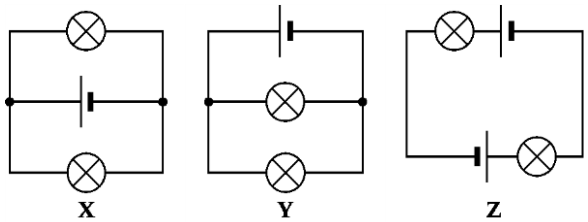
4. Resistance is a way of saying:

A how much electricity is flowing
B how hard it is for electricity to flow
C how many cells are in a circuit
D how many switches are in a circuit

5. Electricity is:

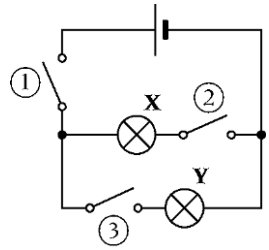
A a source of energy
B a kind of liquid inside the wires
C tiny particles called electrons flowing through the wires
D tiny particles called atoms flowing through the wires

6. Which of these circuits are parallel circuits?



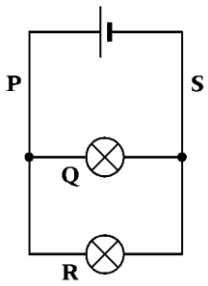
A X and Y only
B X and Z only
C Y and Z only
D all of them

7. Which switches must be pressed to make bulb X come on?



A 1 and 2 only
B 1 and 3 only
C 2 and 3 only
D all three of them

8. Which of these statements is **not** true?



A The currents at Q and R add up to give the current at S.
B The current is the same at P and S.
C The current is the same at Q and R.
D The current is the same at P and Q.

9. Fossil fuels are formed from:

A water
B electricity
C dead plants and animals
D rocks

10. Which of the following is a good electrical conductor?

A plastic
B wood
C aluminium
D glass

11. Which is true?

A renewable energy sources will run out one day
B renewable energy sources will not run out
C non-renewable energy sources will not run out
D none of our energy sources will run out

12. Which of these is a non-renewable energy source?

A solar
B wind
C natural gas
D moving water

13. Which form of energy is often produced as wasted energy?

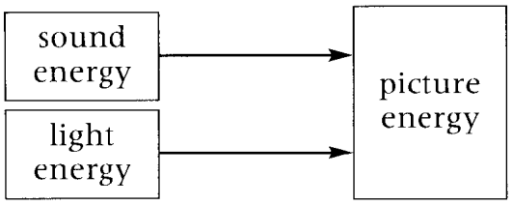
A light
B electricity
C heat
D movement

14. Where does the chemical energy in our bodies come from?

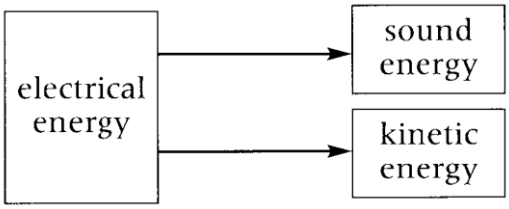
A food
B batteries
C petrol
D gas

15. Which is the correct energy flow diagram for a television?

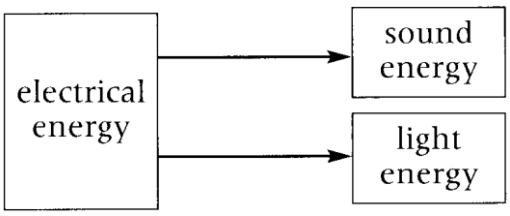
A



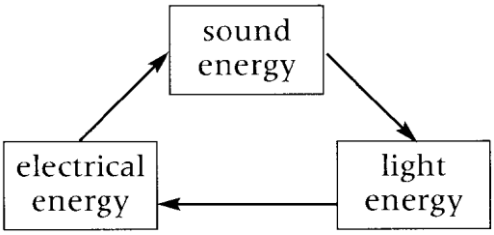
B



C



D



16. In a car engine chemical energy is turned into other forms of energy. Which of these is useful energy?

A kinetic
B heat
C sound
D nuclear

END OF TEST

Appendix 3

Post-innovation assessment

Learning by Questions – content post-assessment

Name: _____

Set: _____

Advice to candidates
You should take **15 minutes for each** of the three different sections.

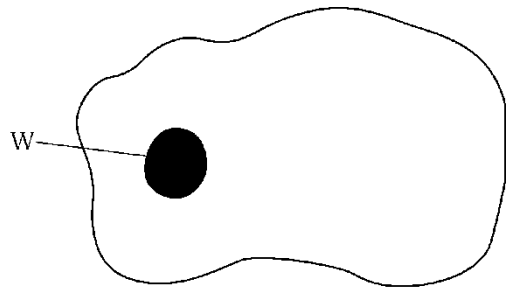
Read all the options before committing to an answer.

Complete all the questions by either circling the answer or writing the letter of the answer next to the question.

If you wish to change an answer simply place a line through the circle and write the letter instead.

Biology content

1. On this drawing of an animal cell, what is the part labelled ‘W’?

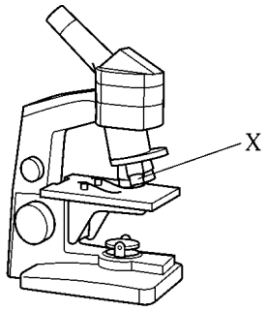


A	cell membrane	**B**	chloroplast
C	nucleus	**D**	Vacuole

2. On the drawing above, what does part ‘W’ do?

A	make energy	**B**	make food
C	control the cell	**D**	acts as the brain

3. On the drawing of a microscope, what is the name of the part labelled ‘X’?

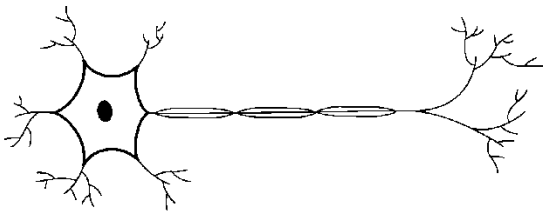


A stage **B** focusing wheel
C objective lens **D** base

4. A microscope has a ×5 eyepiece lens and a ×10 objective lens. The total magnification is:

A ×5
B ×10
C ×15
D ×50

5. What sort of cell is this?



A muscle cell
B root hair cell
C nerve cell

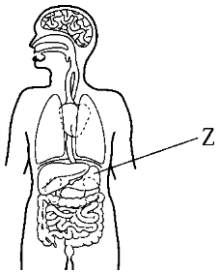
6. A **tissue** is:

A a collection of organs helping each other
B another name for an organ
C a group of cells which are the same, all doing the same job
D a group of cells which are all different, all doing different jobs

7. An **organ** is:

A a group of cells doing different jobs
B a group of tissues helping each other to do a very important job
C a group of cells which are all the same, all doing the same job
D another name for a body

8. In the picture, what is part ‘Z’?



A stomach
B hand
C kidney
D lung

9. An organ system is:

A a collection of organs working together to do an important job
B a collection of tissues that do the same job
C a collection of organs that help us breathe
D a way of counting the number of organs in the body

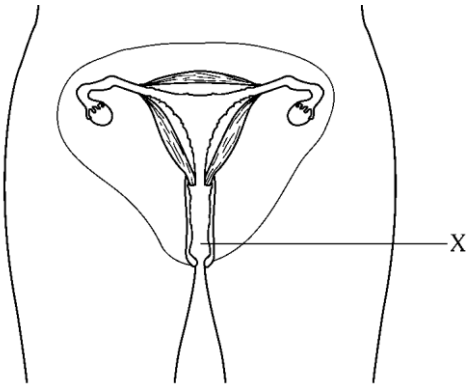
10. Some of the organs in the digestive system are:

A gullet, stomach and ears
B gullet, intestines and lungs
C gullet, intestines and stomach
D kidneys, intestines and heart

11. The sex cells produced in humans are called:

A ovaries and testes
B vagina and penis
C uterus and scrotum
D sperm and egg

12. What is the part labelled ‘X’ in the diagram?



A bladder
B cervix
C uterus
D vagina

13. In males, the scrotum:

A makes semen
B holds the uterus
C holds the testes
D holds the penis in place

14. The loss of blood and the uterus lining in the menstrual cycle is called:

A menstruation
B ovulation
C fertilisation
D urination

15. Fertilisation occurs in:

A an ovary
B a fallopian tube
C the scrotum
D the penis

16. A baby develops inside the:

A vagina
B fallopian tube
C uterus
D ovary

Read the definition and write the key word or phrase

Answer	**Definition**
17.	Part of the cell where energy is released from food molecules.
18.	Group of different tissues working together to carry out a job.
19.	Jelly-like substance where most chemical processes happen
20.	Organ where sperm are produced.
21.	Where the penis enters the female's body and sperm is received.
22.	Liquid that surrounds and protects the foetus.

Chemistry Content

1. A mixture is:

   A just one substance, like pure salt
   B two or more things mixed together, like nuts and raisins
   C two things joined together, like flour and sugar in a baked cake
   D a lot of the same thing put together

2. When something dissolves in water:

   A it splits up and disappears into the water
   B it sinks to the bottom of the water
   C it rises to the top of the water
   D it turns the water a milky colour

3. Filtering cannot be used to separate:

   A sand from a mixture of sand and water
   B sugar from sugar solution
   C tea leaves from a pot of tea
   D leaves from a mixture of leaves and pond water

4. A solid dissolved in water can be obtained by:

   A evaporating the liquid
   B using a sieve
   C using a filter
   D freezing the liquid

5. Which sentence is not true?

   A rock salt is a mixture of rock and salt
   B rock salt can be used to make pure salt to put on food
   C you can get salt from rock salt using a sieve
   D you can get salt from rock salt by dissolving, filtering and evaporating.

6. Pure water is:

   A water which is clean enough to drink
   B water which runs off the hills
   C rain
   D water with nothing dissolved in it

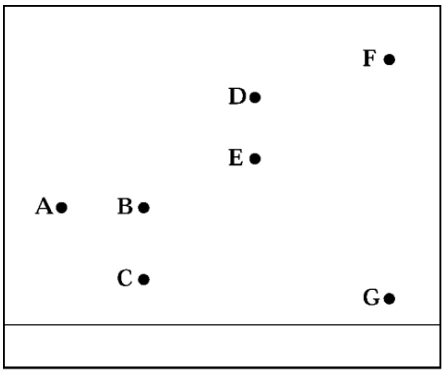
7. Pure water can be made from inky water by:

A filtering it
B evaporating it
C distilling it
D adding more water to it

8. The two steps in distillation are:

A filtering followed by evaporation
B evaporation followed by condensation
C condensation followed by filtering
D filtering followed by condensation

9. The diagram shows a chromatogram. Which two chemicals are the same?



A A and B
B C and B
C D and F
D A and G

10. Everything is made up of:

A particles which are arranged differently in solids, liquids and gases
B particles which are arranged in the same way in solids, liquids and gases
C water particles
D nothing

11. A solid, like rock, has a:

A shape which is easy to change but its volume is fixed
B shape which is fixed but it can change its volume
C shape and a volume which are both easy to change
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A the particles are very close together
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13. All liquids:

A have a fixed volume and take the shape of their container
B have a fixed volume and a fixed shape
C will spread out until their volume has doubled
D can change their volume but not their shape

14. In a liquid:

A the particles are very close together
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C the particles are quite close together
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15. Gases:

A spread out until they fill the space around them
B do not spread out
C cannot be poured
D keep their shape

16. In a gas:

A the particles are held tightly in place by bonds
B there are no particles
C the particles are free to move anywhere
D the strong bonds let the particles move past each other

Read the definition and write the key word or phrase

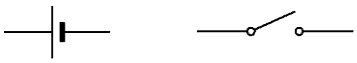
Answer	**Definition**
17.	Change from liquid to a solid when the temperature drops to the melting point
18.	Change of state from gas to liquid when the temperature drops to the boiling point.
19.	Change from solid to liquid when the temperature rises to the melting point.
20.	A substance that can dissolve in a liquid.
21.	A substance that will not dissolve in a liquid.
22.	Separating substances by boiling and condensing liquids.

Physics Content

1. Which of these statements is true?

A Plastic is a conductor because it lets electricity flow through it.
B Plastic is an insulator because it lets electricity flow through it.
C Metals are conductors because they let electricity flow through them.
D Metals are insulators because they let electricity flow through them.

2. What do these symbols show?



A a cell and a bulb
B a cell and a switch
C a bulb and a switch
D a switch and a motor

3. Which instrument would you use to measure current?

A an ammeter
B a cell
C a motor
D a voltmeter

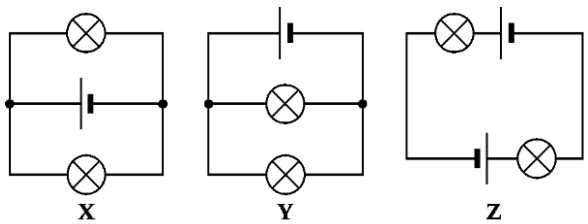
4. Resistance is a way of saying:

A how much electricity is flowing
B how hard it is for electricity to flow
C how many cells are in a circuit
D how many switches are in a circuit

5. Electricity is:

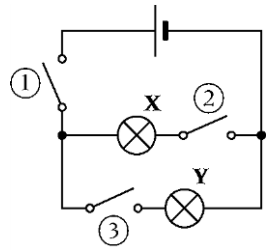
A a source of energy
B a kind of liquid inside the wires
C tiny particles called electrons flowing through the wires
D tiny particles called atoms flowing through the wires

6. Which of these circuits are parallel circuits?



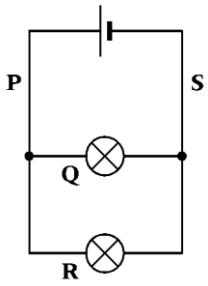
A X and Y only
B X and Z only
C Y and Z only
D all of them

7. Which switches must be pressed to make bulb X come on?



A 1 and 2 only
B 1 and 3 only
C 2 and 3 only
D all three of them

8. Which of these statements is **not** true?



A The currents at Q and R add up to give the current at S.
B The current is the same at P and S.
C The current is the same at Q and R.
D The current is the same at P and Q.

9. Fossil fuels are formed from:

A water
B electricity
C dead plants and animals
D rocks

10. Which of the following is a good electrical conductor?

A plastic
B wood
C aluminium
D glass

11. Which is true?

A renewable energy sources will run out one day
B renewable energy sources will not run out
C non-renewable energy sources will not run out
D none of our energy sources will run out

12. Which of these is a non-renewable energy source?

A solar
B wind
C natural gas
D moving water

13. Which form of energy is often produced as wasted energy?

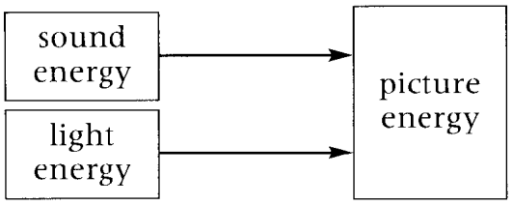
A light
B electricity
C heat
D movement

14. Where does the chemical energy in our bodies come from?

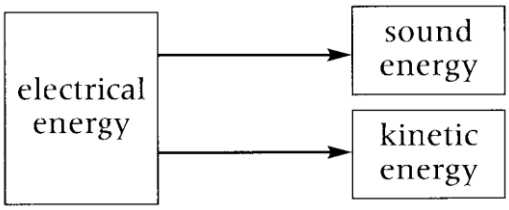
A food
B batteries
C petrol
D gas

15. Which is the correct energy flow diagram for a television?

A



B



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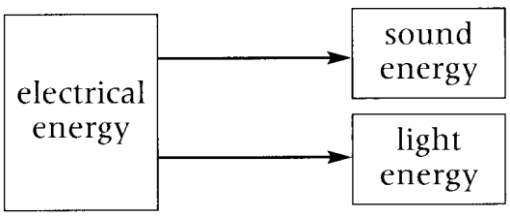
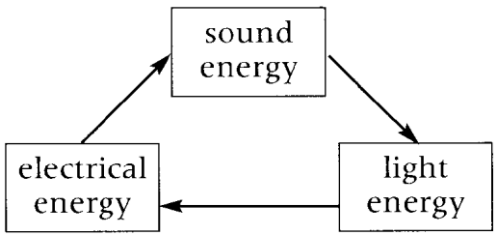


D



16. In a car engine chemical energy is turned into other forms of energy. Which of these is useful energy?

A kinetic
B heat
C sound
D nuclear

Read the definition and write the key word or phrase

Answer	**Definition**
17.	Flow of electric charge, in amperes (A).
18.	If components in a circuit are on the same loop.
19.	If some components are on separate loops.
20.	The energy store filled when an object is warmed up
21.	The energy store filled when an object speeds up.
22.	How quickly energy is transferred by a device (watts).

END OF TEST

Contact us

+44 (0)1904 328166 | info@the-iee.org.uk
Ron Cooke Hub, University of York, York YO10 5GE
Twitter: @IEE_York | the-iee.org.uk/

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