



T-LEVELS
THE NEXT LEVEL QUALIFICATION

T Level resource improvement project

**T Level in Science – formative assessment
materials for core content and assessment
objectives AO1, AO2 and AO3**

This set of resources was developed as part of a T Level resource improvement project (TRIP) which ran from April to June 2022.

The resource consists of a set of formative assessment questions to support learners in developing the necessary skills and understanding to answer AO1, AO2 and AO3 questions in the core exams for the T Level in Science. Each question indicates the core content to which it applies (eg A10 or B1.23) and answers and indicative content are also provided.

AO1 questions require learners to demonstrate knowledge and understanding of the core content. Although they are recall questions, they can still require learners to provide detailed explanations of complicated principles, theories and concepts.

AO2 questions require learners to apply knowledge and understanding of core content to different situations and contexts, which may be unfamiliar to them. In this case, the assessment is of learners' ability to apply their knowledge and understanding rather than their ability to recall.

AO3 questions require learners to analyse and evaluate information and issues related to content. Learners are presented with information – results, diagrams, written text or graphs – that they will need to use in order to answer the question.

AO1 formative assessment materials

A10

A commercial microbiology lab purchases the new equipment listed in the table below. Match each piece of equipment to its use.

Equipment		Use
Autoclave		to provide a controlled and accurately maintained environment (eg in terms of temperature or humidity)
Digital pipette		to provide a contained and controlled environment (sealed atmosphere) for manipulating samples, substances and objects
Centrifuge		to accurately measure and transfer solutions
Incubator		to separate suspensions
Glove box		to decontaminate/sterilise equipment and some consumables

Answer

Equipment	Use
Incubator	to provide a controlled and accurately maintained environment (eg in terms of temperature or humidity)
Glove box	to provide a contained and controlled environment (sealed atmosphere) for manipulating samples, substances and objects
Digital pipette	to accurately measure and transfer solutions
Centrifuge	to separate suspensions
Autoclave	to decontaminate/sterilise equipment and some consumables

A4

A new technician has started working in the lab. They have just graduated from university with a degree in microbiology but have no experience of working in a commercial laboratory.

Describe the training that they should receive during their induction for the job, considering:

- health and safety legislation

- personal protective equipment
- standard operating procedures

Indicative content

- Health and Safety at Work Act
- Management of Health and Safety at Work Regulations
- Control of Substances Hazardous to Health (COSHH) Regulations
- Personal Protective Equipment at Work Regulations
- Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR)
- Environmental Protection Act
- Special Waste Regulations
- Hazardous Waste Regulations
- Regulatory Reform (Fire Safety) Order (RRO)
- Manual Handling Operations Regulations
- Health and Safety (Display Screen Equipment) Regulations
- Health and Safety Executive's Five Steps to Risk Assessment

A4.6

A pharmaceutical company is researching drugs for the treatment of infection caused by MRSA. The lab generates a large variety of different types of waste. Apply your knowledge of hazard groups to categorise each of the different types of waste in the table below. Label each type of waste 1, 2, 3 or 4 according to its category of hazard.

Type of waste	Category of hazard
A glove worn by a technician when cleaning the lab bench	
An empty cardboard box from a delivery of new Petri dishes	
Blood samples from patients suspected of being infected with MRSA	

A paper towel used by a staff member for drying their hands before entering the lab	
A disposable apron worn by a lab technician	
Patient samples left over from the lab's previous research on chickenpox	

Answer

Type of waste	Category of hazard
A glove worn by a technician when cleaning the lab bench	2
An empty cardboard box from a delivery of new Petri dishes	1
Blood samples from patients suspected of being infected with MRSA	4
A paper towel used by a staff member for drying their hands before entering the lab	1
A disposable apron worn by a lab technician	2
Patient samples left over from the lab's previous research on chickenpox	3

B1.32

Research paediatricians are studying the immune response of newborn babies. When a baby is breastfed it receives some of its mother's antibodies. The baby then has some immunity against diseases to which its mother is immune.

Describe two differences between the immunity obtained from breastfeeding and the immunity obtained from a vaccine.

Indicative content

- The baby receives immediate immunity from breastfeeding.
- Immunity from a vaccine takes time to develop.
- Immunity from a vaccine means exposure to an antigen.
- Immunity from breastfeeding does not require exposure to an antigen.
- Vaccines result in the production of memory cells.
- Immunity from breastfeeding does not result in the production of memory cells.
- Immunity from a vaccine lasts longer.

B1.21

A hospital pathology laboratory is considering purchasing a new microscope. The lab conducts several procedures on different types of biological samples. Complete the table below to identify the most suitable type of microscope to use for each of the human specimens listed.

Specimen	Type of microscope
Human papillomavirus particles	
Ribosomes in liver cells	
Semen containing living sperm cells	
Cervical cells taken from a cervical smear	
The inner structure of a mitochondrion	

Answer

Specimen	Type of microscope
Human papillomavirus particles	Scanning electron microscope
Ribosomes in liver cells	Transmission electron microscope
Semen containing living sperm cells	Light microscope
Cervical cells taken from a cervical smear	Light microscope or laser scanning microscope
The inner structure of a mitochondrion	Transmission electron microscope

A3.1

Complete the following table for two pieces of legislation in the health and science sector.

	Example one	Example one
Name of legislation		
Purpose of legislation		

Indicative content

- Health and Safety at Work Act etc.1974: defines employers' responsibilities to protect the health, safety and welfare at work of employees and members of the public and defines employees' duties to protect themselves and each other

- Management of Health and Safety at Work Regulations 1999: aim to reduce the number and severity of accidents in the workplace through assessment and management of risk
- Control of Substances Hazardous to Health (COSHH) Regulations 1994 (amended 2002): require employers to control substances hazardous to health by reducing or preventing employees' exposure to these substances
- Personal Protective Equipment at Work Regulations 1992: define employers' responsibilities to provide appropriate personal protective equipment (PPE) – including safety helmets, masks, goggles and gloves – to reduce harm to employees, visitors and clients
- Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013 (RIDDOR): define employers' duties to report serious workplace accidents, occupational diseases and specified dangerous occurrences ("near misses")
- Environmental Protection Act 1990: makes provision for the improved control of pollution to the air, water and land by regulating the management of waste and the control of emissions
- Special Waste Regulations 1996: specify measures relating to the regulation and control of the transit, import and export of waste (including recyclable materials), the prevention, reduction and elimination of pollution caused by waste and the assessment of the environmental impact of projects that are likely to have a significant effect
- Hazardous Waste Regulations 2005: control the storage, transport and disposal of hazardous waste (waste stream) to ensure it is appropriately managed and any risks are minimised
- Waste Electrical and Electronic Equipment (WEEE) Regulations 2012/19/EU: aim to reduce the amount of electronic and electrical equipment incinerated or sent to landfill sites, placing the onus on all businesses to correctly store and transport electrical waste
- Regulatory Reform (Fire Safety) Order (RRO) 2005: aims to reduce death, damage and injury caused by fire by placing legal responsibilities on employers to carry out a fire risk assessment and to have procedures for evacuation in the event of a fire
- Manual Handling Operations Regulations 1992 (updated 2002): require employers to assess and minimise the risk to the health of employees involved in the manual handling, moving and positioning of an object, person or animal and to consider workplace ergonomics

- Health and Safety (Display Screen Equipment) Regulations 1992: define employers' responsibilities to carry out risk assessments of workstations used by employees, including the use of display screen equipment, to minimise identified risks

B1.25 and B1.27

a) Draw a line to link the condition to the microorganism that causes it:

Thrush

Bacteria

Malaria

Protoctist

Tuberculosis

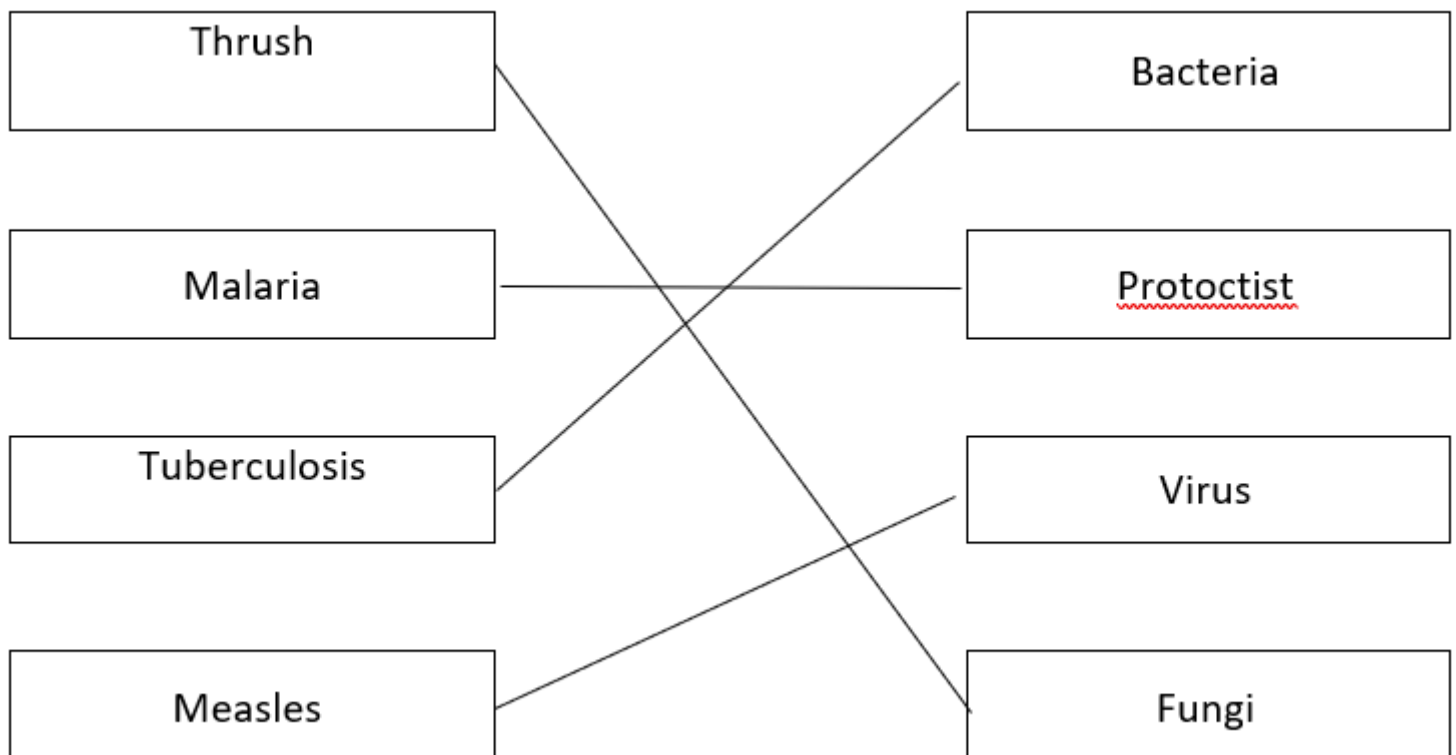
Virus

Measles

Fungi

b) Describe how infectious diseases can spread among populations and communities.

Answer (a)



Indicative content (b)

- unclean water / poor sewage / lack of sanitation, for example bacterial and fungal growth
- lack of social distancing / dense populations, for example airborne transmission through sneezes
- poor healthcare, for example, lack of treatment so that microorganism has time to spread

B2.11

At the end of glycolysis, two molecules of reduced NAD, two molecules of pyruvate and two molecules of ATP are produced. Explain the process of glycolysis and the chemical reactions that occur to reach this stage. Include diagrams to support the explanation

Indicative content

- The process starts with glucose – 6 carbons.

- The sequence should follow: glucose (6C) – fructose 1, 6 biphosphate (6C) – triose phosphate (3C) – pyruvate (3C).
- Phosphorylation is the process of adding a phosphate group. Glucose is phosphorylated using a phosphate from a molecule of ATP. ATP is then used to add another phosphate and triose phosphate is then formed.
- Oxidation is another chemical reaction that occurs and, here, triose phosphate loses hydrogen atoms. NAD collects these hydrogen atoms and forms two reduced NAD.

B2.3

Complete the sequence of bases in the mRNA strand.

DNA strand	C	C	T	G	T	A	C	G	G	T	A	A
mRNA strand												

Answer

DNA strand	C	C	T	G	T	A	C	G	G	T	A	A
mRNA strand	G	G	A	C	A	U	G	C	C	A	U	U

B2.18

Uranium-235 is a common element used in nuclear power. It is an isotope. Explain what would make this isotope unstable.

Indicative content

- too many / an excess of protons
- too many / an excess of neutrons
- too much mass in the nucleus
- an imbalance of protons and neutrons

B2.1

Explain how ATP is suited to its function.

Indicative content

- ATP can diffuse quickly as it is small and soluble.

- ATP cannot leak out of the cell as it is polar and, therefore, will not diffuse across the phospholipid bilayer of the plasma membrane.
- Energy can be transferred quickly as ATP can be hydrolysed rapidly.

B1.32

a) Define an antigen.

b) Compare the actions of B cells and T cells in the human immune response.

Indicative content

a) Antigens:

- are proteins
- are present on the surface membranes of all cells
- allow the identification of cells
- can be self or non self

b)

B cells:

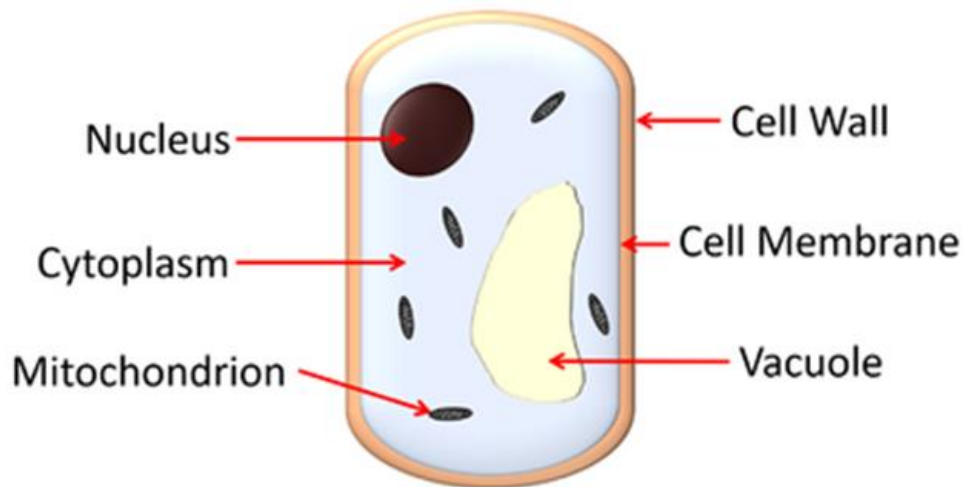
- produce antibodies
- produce memory cells
- are specific to particular pathogens
- assist with long-term immunity
- must be activated

T cells

- can destroy pathogens with toxins/cytotoxins (ignore poison or other)
- must be activated
- can be helper T cells
- helper T cells activate other immune cells

B1.20

The image below shows a labelled diagram of a cell



To which kingdom of life does the cell above belong?

- a) animals
- b) plants
- c) fungi
- d) bacteria

Explain your answer.

Answer

- c) Fungi

Indicative content

- cell wall / vacuole rules out animal cell
- nucleus/mitochondria/vacuole rules out bacteria
- lack of mitochondria suggests not a plant
- lack of bacterial structures (e.g. pili or flagellum plasmid)

B2.3 and B1.30

HIV is a virus that invades the nucleus of T cells and infects them with its viral DNA. Suggest how, over time, this leads to a HIV infection in the body and, ultimately, to the symptoms of AIDS.

Indicative content

- viral RNA becomes viral DNA
- viral RNA/DNA copied or transcribed
- MRNA produced containing viral RNA
- MRNA used for protein synthesis/translation
- T cell(s) dies (die) / produces (produce) new HIV viruses
- number of T cells in body reduced
- T cells cannot fight infection / immune system less effective
- symptoms develop as infection increases

AO2 formative assessment materials

A10.4

Research scientists are investigating how potassium can improve the efficiency of solar cells.

Explain why scientists have added using tongs, storing in oil and controlling disposal methods as control measures to the risk assessment for using potassium in this investigation.

Indicative content

- Tongs prevent skin contact with alkali metal as moisture on skin would cause a violent reaction.
- Tongs allow scientists to handle alkali metal at a greater distance.
- Metal is stored in oil to prevent reaction with oxygen.
- Disposal must be controlled as alkali metal would react violently with water in drains.

A10

A commercial microbiology lab tests food products for potentially harmful microorganisms.

a) Food samples are delivered to the lab on a daily basis. Describe why the technician who receives these food samples and prepares them for testing must follow aseptic techniques.

b) A technician has been ill with sickness and diarrhoea. They are asked not to return to work for at least 48 hours. Explain the reason for the company having this policy.

Indicative content

a) The technician must follow aseptic techniques because they:

- are procedures and practices to prevent contamination
- are needed to prevent contamination of the samples by the technician or the lab environment
- are needed to prevent contamination of the lab by potential pathogens present in the sample

- are needed to prevent cross contamination between samples
- could lead to invalid results

b) The company has this policy:

- to prevent other workers from becoming ill
- to prevent cross contamination between the ill worker and the food samples

A2

A post-surgical hospital ward has been identified as having a higher than expected number of cases of MRSA. It is suspected that this is a result of staff members on the ward not complying with the hospital's regulatory controls. Describe the regulatory controls that should be in place on this ward.

Indicative content

- Staff must know the type and level of personal protective equipment required and use it in accordance with SOPs.
- Staff must follow the required standards of health and safety and housekeeping.
- Staff must attend mandatory training to comply with guidance or legislation and refresh this training as required.
- Staff must be trained in requirements for the safe disposal of waste.
- Staff must follow all controls specified in SOPs.

A2.10

At a national food testing laboratory, samples are tested to confirm that the nutrients present and the concentrations at which they occur agree with the labelling that companies provide for consumers.



Instrument calibration is part of quality assurance procedures at this laboratory.

Explain the consequences of poor quality assurance procedures at this laboratory.

Indicative content

- Poor quality assurance may lead to the food supplier ending the contract and using another laboratory for testing services.
- Poor quality assurance may lead to negative media coverage for the food supplier if unknown ingredients are present.
- Poor labelling may cause death or serious illness as a result of the presence of allergens not being recorded.
- Legal action may be required as a result of the consequences of poor labelling posing a danger to consumers.
- Consumers following specific dietary requirements linked to medical conditions may be misled by errors in food labelling.
- The recall of batch numbers when issues occur may be delayed due to errors in the lab, which may cause risk to consumers.
Poor calibration of machines may mean allergens present in trace amounts are not identified.

A2.10

A disposable glove manufacturer produces two types of glove. One is designed for medical settings and can be used to handle biohazardous waste. The other is designed to be used in a domestic setting for general household cleaning.

Describe and explain how the quality control and quality assurance procedures would differ for the two different types of glove.



Indicative content

Quality control and quality assurance procedures need to be more rigorous for the medical gloves.

Quality control:

- testing the medical gloves for prevention of contamination, elasticity and ease of use
- testing the domestic gloves for durability when in contact with cleaning products
- more testing to be done on medical gloves
- medical gloves must follow government guidance and meet standards for use in the NHS
- more batch testing of medical gloves

Quality assurance:

- greater monitoring of processes for medical gloves
- better quality environment (sterile) for the manufacture of medical gloves
- more monitoring of raw materials for medical gloves
- any other valid points

A5

The manager of a fertility clinic has been contacted by police to say that the clinic's office has been broken into and the office computer has been stolen. Explain why this is a problem and the steps that the clinic should now take.

Indicative content

- patient/client personal information may be accessed
- Data Protection Act / General Data Protection Regulation (GDPR) has been breached
- potential theft of personal data should be reported to the government/authorities
- patients/clients should be informed
- any other valid points

A6

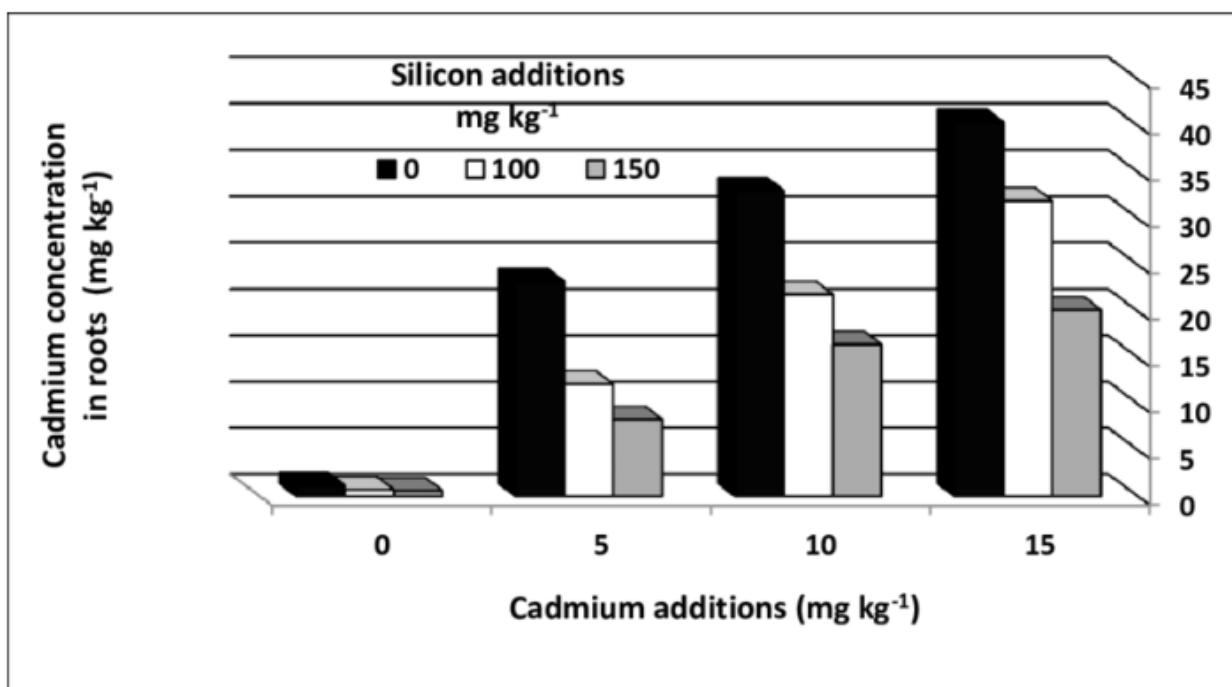
You are working as the manager of a genetic testing laboratory. An experienced researcher prefers to record their results in handwritten lab notebooks. You would like them to start using the laboratory information management systems (LIMs). What reasons would you outline to the researcher to ensure they use LIMs rather than their handwritten notes?

Indicative content

- LIMs enables data visualisation and reports
- data are easily shared
- data can be searched
- data can be accessed remotely
- cloud storage ensures safety from physical damage
- errors in the system or the data can be highlighted

A6.1

Analytical chemists at an agrochemical firm working on brownfield sites are investigating how cadmium (a toxic metal) accumulates in the roots of lettuce plants. The figure below displays the results of the investigation.



The chemists' hypothesis is that adding silicon to the soil reduces the cadmium concentration in the lettuce roots.
Describe how the trends in the data provided in the figure support this hypothesis.

Indicative content

Data in the figure should be referred to as much as possible and may include:

- increasing the cadmium concentration from 0 to 15mg/kg leads to an increase in cadmium uptake in the roots of the lettuce
- when no silicon is added and the cadmium concentration is increased from 0 to 5mg/kg, then the amount of cadmium in the roots increases from 2 to 22mg/kg
- when 100 mg/kg of silicon is added and cadmium additions increase from 0 to 5mg/kg, the amount of cadmium in the roots increases from 1 to 11mg/kg
- at 5mg of cadmium, adding 100 mg/kg of silicon reduces uptake in the roots by 50 per cent
- at 10 and 15 mg/kg of cadmium, 150 mg/kg of silicon needs to be added to reduce uptake by 50 per cent
- the data supports the hypothesis but at higher concentrations of added cadmium, more silicon is needed to reduce uptake in the roots

A7

An e-cigarette is a device that allows the user to inhale nicotine through vapour rather than smoke. Company A has developed a new type of e-cigarette which, it claims, will reduce the user's dependence on nicotine. The company has registered a trademark for the name of their new product.

Explain what other forms of intellectual property protection the company may need for their new e-cigarette.

Indicative content

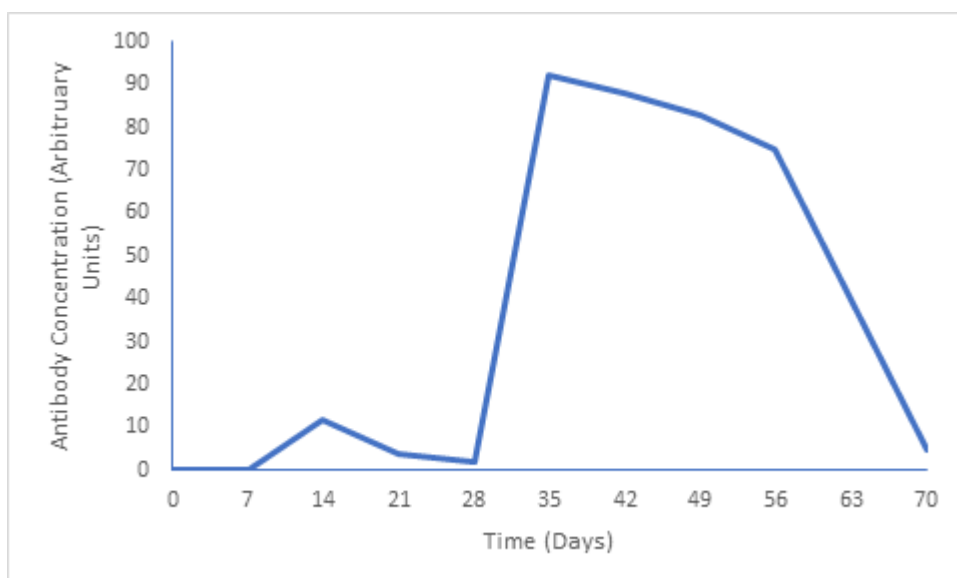
- patent: used to protect ownership of an invention or new process; stops rivals copying the idea for a set number of years
- trademark: protection of logo, phrase or business name that is registered with the government

A7 and B1.32

a) A vaccine has been developed to help reduce the spread of Covid. Give one ethical argument against making the Covid vaccination mandatory for all UK citizens.

b) The government would like to encourage people to get vaccinated against Covid. Explain how a person receiving the Covid vaccine will develop immunity against the disease.

c) The graph below shows the concentration of antibodies in an individual's blood after receiving the Covid vaccine and following subsequent infection with the virus.



Explain the shape of the line on the graph. In your answer refer to the reason for the first small peak and the second much larger peak.

Indicative content

a) Ethical argument against making the Covid vaccination mandatory:

- people should have autonomy and choice over what goes into their bodies
- some people do not trust the efficacy of the vaccine
- some people do not trust the safety of the vaccine

b) How a person develops immunity:

- vaccine contains (Covid) antigen
- antigen displayed on cell surface of antigen-presenting cell (APC) / macrophage/dendritic cell
- clonal selection of lymphocytes
- clonal expansion/proliferation by mitosis
- B/plasma cells release antibodies against antigen/Covid
- lymphocytes **differentiate** into memory cells, which last a long time
- response is greater/faster if Covid / same antigen enters body
- booster / more than one vaccination required

c) Reasons for the shape of the line on the graph:

- after first exposure to the antigen, antibody levels remain low for several days because there are few B cells to produce antibodies
- antibodies then increase as B cells produce plasma cells, which rapidly produce antibodies – this is the first peak
- the line on the graph then falls as plasma cells dies off
- the line does not drop to pre-exposure levels because memory cells remain
- the second exposure produces a quicker response, which is indicated by the steeper curve
- the quicker response is the result of the presence of previous antibodies and memory cells, which can rapidly produce more antibodies
- the second exposure produces greater antibody levels, indicated by a higher second peak, because of the presence of previous antibodies and memory cells, which can rapidly produce more antibodies

A8

A lab technician returns to work on a Monday morning to discover that there has been a power outage in the lab over the weekend. The lab fridge, which contains some stock chemicals, is off and is now at room temperature. Suggest why this is a problem and what should be done with the chemicals.

Indicative content

- degradation of reagents as no longer stored at correct temperature
- risks to health and safety due to release of dangerous chemicals
- chemicals should be disposed of
- correct disposal of chemicals
- financial loss
- impact on stock management

A8

The figure below shows a SOP for preparing one batch of trypan blue stain.

Trypan Blue Staining

Materials

- 2 x Trypan Blue stain.
 1. 80 ml Lactic acid (Sigma L-1250)
 2. 60g Phenol
 3. 80ml 100% Glycerol
 4. 80 ml dH₂O
 5. 80mg Trypan blue
- Chloral hydrate de-stain solution.
 1. 25g Chloral hydrate
 2. 10ml dH₂O

Method

1. Dilute Trypan Blue stain solution 1:2 with ethanol before use
2. Immerse leaf samples in trypan blue stain solution.
3. Place bottles in a pan of boiling water.
4. Leave bottles in the pan until the stain in the bottle also boils. Let sit for 3 mins.
5. Take the pan off the heat, with the bottles still inside and leave to cool in pot for 1 hours (30 min).
6. Transfer samples to de-stain solution and view the next day.
7. Mount in water or 50% glycerol.

Notes

Leaves can be cleared before Trypan Blue staining to remove chlorophyll and other pigments.

A bioimaging laboratory working on plant samples is operational seven days a week. Technicians in the laboratory make up two batches of trypan blue stain every week to use in plant material testing.

a) Calculate how long (the nearest number of days) a one-litre container of lactic acid will last.

b) Suggest reasons why the lactic acid may need restocking sooner than the time you have calculated above.

Indicative content

a) Calculation:

1 litre = 1000ml

1000ml/120ml

8.3333 weeks x 7 = **58 days**

b) Reasons:

- spillage/wastage
- higher demand for testing from clients some weeks / response to market demand

B1.27

Covid is an infectious respiratory disease caused by the SARS-CoV-2 virus and spreads primarily through the air. Explain two reasons why Covid is more likely to spread in less economically developed communities.

Indicative content

All answers should be in the context of less economically developed communities.

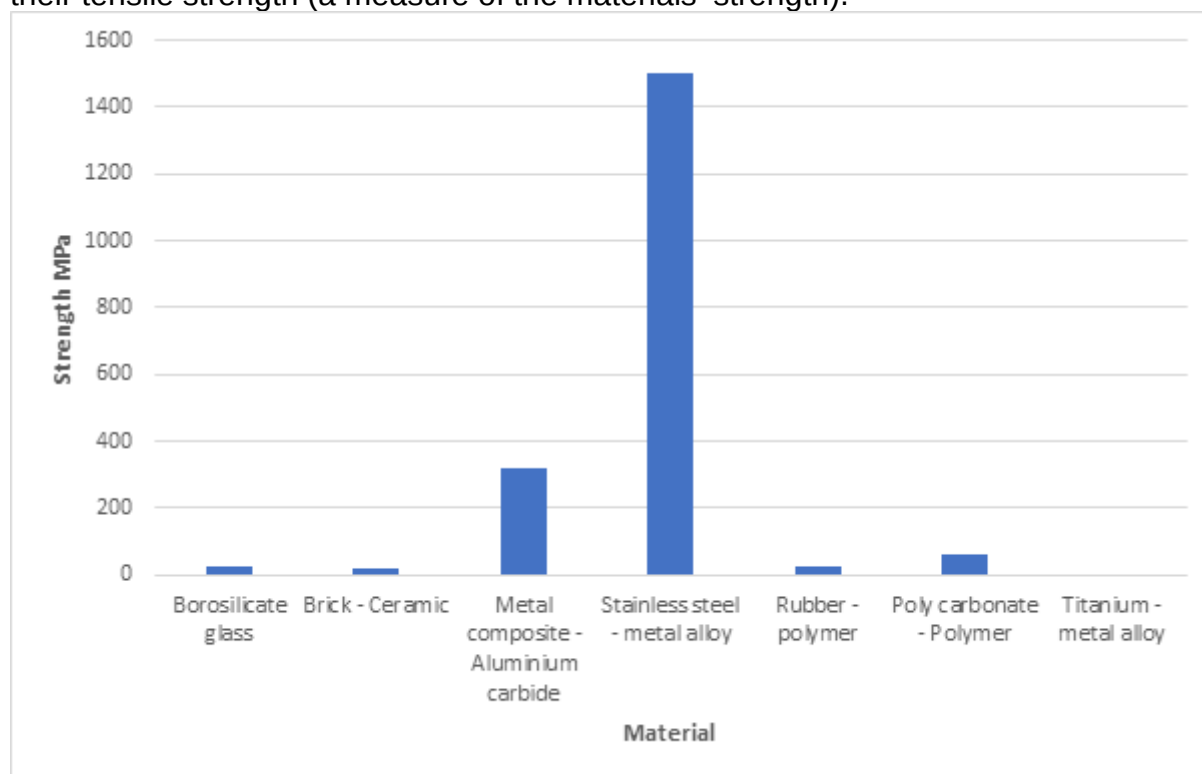
In less economically developed communities, there is likely to be:

- overcrowding – this will lead to lack of social distancing which will increase the spread of airborne infection
- poor sanitation
- Inadequate healthcare/infrastructure
- lack of accessible health promotion information

B1.33

A regional quality assurance laboratory checks the properties of materials used in a range of manufacturing industries.

The graph below shows of a sample of the materials tested and includes details of their tensile strength (a measure of the materials' strength).



Complete the graph by adding data for the titanium metal alloy, which is published as being 800MPa.

Suggest a reason for the difference in strength between the stainless steel metal alloy and the titanium metal alloy.

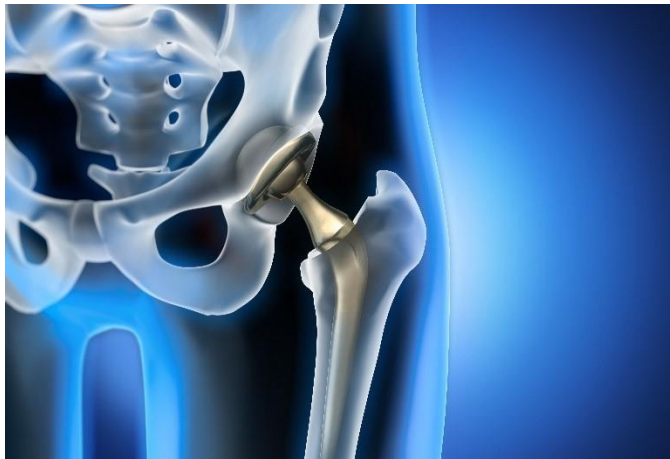
Indicative content

a) Bar added to 800MPa

b) Reasons for difference in strength:

- different proportion of metals combined
- stainless steel may have a higher charge on its positive ions and, therefore, a large number of delocalised electrons
- any issues during manufacture, for example, irregularities that may reduce strength

B1.33



Hip replacement is a surgical procedure in which the hip joint is replaced by a prosthetic implant. Strength is one property that a material used for this application requires. Describe three additional properties that would also be considered when selecting a material for this surgical procedure.

Indicative content

- malleability to mould metal to a shape which fits the individual's existing bone shape
- inert/unreactive metal to prevent corrosion in the body
- low density / similar density to existing bone to promote rehabilitation

B1.63

Tuna consumption

Species of tuna	Mercury (in mcg) per 85g serving
Light tuna (canned)	10.71
Skipjack tuna steak (fresh or frozen)	12.24
Albacore tuna (canned)	29.75
Yellowfin tuna steak (fresh or frozen)	30.09
Albacore tuna steak (fresh or frozen)	30.43
Bigeye tuna steak (fresh or frozen)	58.57
Body weight (kg)	Maximum safe dose (in mcg*)
45	31.5
57	39.9
68	47.6
80	56.0
91	63.7

* 1mcg = 0.001mg

Pregnant women are advised by health professionals to limit tuna consumption because it contains more mercury than other fish. Too much mercury can be harmful to an unborn baby.

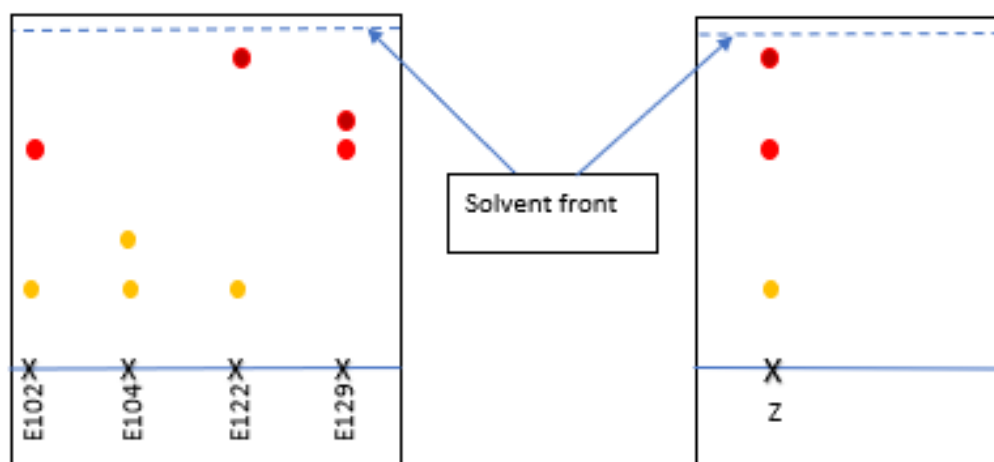
Discuss whether the advice that four canned servings of tuna or two tuna steaks a week would be appropriate for a pregnant woman (68kg body weight) to stay within the maximum safe dose.

In your answer include calculations of the mercury dose for a range of combinations of servings from the options presented in the figure above.

Indicative content

- 68kg woman – maximum consumption of 47.6mcg
- $4 \times 10.71 = 42.84$ – light tuna (canned) within the limit
- $4 \times 29.75 = 119$ albacore tuna (canned) exceeds the limit
- $2 \times 12.24 = 24.48$ skipjack tuna steak within the limit
- $2 \times 30.09 = 60.18$ yellowfin tuna steak exceeds the limit
- guidance appropriate depending on tuna type
- light tuna and skipjack tuna have lower mercury levels so the advice is appropriate in those instances

B2.28



When foods are imported into the EU additives need to be matched to known and approved E numbers.

Analytical chemists have carried out paper chromatography to identify an unknown colouring (Z), which they suspect is made from a mixture of two colourings.

- Identify which two E-number additives are present in colouring Z.
- Justify your answer by calculating R_f values for the substances.

Indicative content

a) Additives present:

- E102
- E122

b) R_f values:

- three examples of R_f value calculated
- matched values of known E numbers to values for Z

B1.21

A hospital pathology laboratory is considering purchasing a new microscope. The lab conducts several procedures on different types of biological sample.

The hospital secures the funding to purchase a new electron microscope. List the advantages and disadvantages of the pathology laboratory using an electron microscope.

Indicative content

Advantages:

- high resolution
- high magnification
- can be used to observe very small samples such as virus particles and ribosomes

Disadvantages:

- expensive
- large
- not portable
- skill and training needed for use
- cannot be used on living specimens such as some biological samples
- produces black and white images only

B2.20

A technician working for the Environment Agency collected samples from waste pipes at a chemical plant. The technician monitored the concentration of sulfuric acid in the liquid waste before it was discharged into the river.

In the laboratory they carried out a titration to calculate the concentration of the acid. They placed 25.00cm³ of the sulfuric acid waste in a conical flask. This was neutralised by titrating 8.30cm³ of sodium hydroxide with a concentration of 0.05dm⁻³.

The equation for this reaction is:



a) Balance the equation for this reaction.

b) Use the data provided to calculate the concentration of the acid.

Indicative content



b) Calculation:

$$(8.30/1000) \times 0.05 = 0.0004$$

$$\text{ANS}/2 = 0.0002$$

$$\text{ANS}/(25/1000) = \mathbf{0.0083 \text{ mol dm}^{-3}}$$

A1.1

Apprentice laboratory technicians at a material testing laboratory have a monthly performance review scheduled with their supervisor. The meeting discussions are recorded in a logbook under the following sections:

- reviewing work performance against objectives from previous meetings
- acting on feedback from supervisor
- raising concerns
- planning continuing professional development

Explain the benefits of this process for the apprentice and for the material testing company.

Indicative content

Apprentice:

- opportunity to review work against standards required for the apprenticeship
- achievements related to meeting set targets are recognised
- where targets are not met a plan is put in place to meet them before the next review
- time to understand feedback from supervisor and clarify what it means
- concerns about procedures / health and safety issues are discussed

Material testing company:

- performance review could form part of the quality assurance process at the laboratory
- investing time in reviewing apprentice performance will help them work towards a qualification that could lead to additional roles in the organisation
- improves employee retention and reduces time spent recruiting
- health and safety issues are highlighted and can be dealt with before there is an incident
- feedback may help to improve future apprenticeship programmes
- enables the identification of continuing professional development (CPD) needs for the workforce

A10.6

A laboratory technician working at a water treatment plant would like to examine and measure the size of some living single-celled eukaryotic organisms found in a sample of drinking water.

a) Describe how they should prepare the microscope slide and how they would illuminate the specimen under the microscope.

b) Explain why it may be difficult to focus this specimen under the highest magnification of a light microscope.

c) The technician discovers daphnia (water fleas) in the water sample. She records their length as ranging from 0.2 to 3.0mm. Express this range of measurement in micrometres and include the correct unit symbols.

Indicative content

a) Procedure:

- Use a cavity slide.
- Put a drop of the sample water into the cavity.
- Add a stain (optional).
- Place a coverslip over the sample.
- Observe using low power illumination.

b) The specimen has depth. Therefore, at the highest magnification the lenses cannot focus on the nearest and farthest part of the sample at the same time.

c) 200–3000µm

A7

The marketing department of tobacco company is planning to advertise their new e-cigarettes using a social media campaign aimed at 18–25 year olds. What are the potential ethical issues related to this campaign?

Indicative content

- The marketing campaign was aimed at younger people. E-cigarettes should be used to help established smokers quit and 18–25 year olds are unlikely to be established smokers.
- The campaign could encourage 18–25 year olds to develop a nicotine addiction.
- The campaign should have been run in conjunction with the NHS or a government body.

A10.3

A laboratory technician wants to carry out an experiment to investigate the antibiotic resistance of bacteria. Complete the following table to outline the equipment they might need and the purpose of that equipment for the investigation.

Equipment	Purpose
Bunsen burner	To create uplift and sterilise air in the experimental area

Indicative content

Examples of paired answers include:

- autoclave – to dispose of bacteria / to sterilise equipment
- incubator – to control temperature / set optimum temperature
- disinfectant/Virkon – to sterilise equipment/worktops

Other equipment could include:

- petri dishes
- bacteria culture of known dilution
- volumetric pipettes
- PPE such as goggles/gloves

A6.11

A scientist is reviewing the results of an investigation, which aimed to determine the number of people that actively support the use of renewable technologies. The scientist has noticed that the sample of people in the investigation were all from one age group. Explain the impact of this finding on the investigation.

Indicative content

- Investigation is biased as it only reports on findings from one specific age group.
- Inaccurate findings may be inferred from the results, which could lead to an incorrect conclusion.
- The investigation was a waste of time and resources and, therefore, could be quite costly.
- This may result in damage to the reputation and, ultimately, the credibility of present and future work.

A6.11

Two laboratory technicians have been carrying out investigations into a new drug for the treatment of headaches. Technician A has collected quantitative data from patient interviews and technician B has collected qualitative data on the amount of the drug present in patient blood samples. Explain the benefits of collecting quantitative rather than qualitative data in this investigation.

Indicative content

- quantitative data will be objective and measurable and can be defined as a value
- there are fewer variables involved
- data are likely to be less biased and more accurate
- easier to obtain a larger sample size
- qualitative data is subjective and time consuming to collect

A6.3

A small laboratory that tests food samples is considering the possibility of investing in a laboratory information management system (LIMS). Explain the advantages and disadvantages to the laboratory of using a LIMS.

Indicative content

Advantages include:

- enables reports to be generated in variety of formats
- easy storage
- search facilities
- remote access
- cannot be physically damaged
- highlights errors
- can set access passwords / restrict data to different users
- takes up no physical space
- can be accessed anywhere in the world
- quicker searching for data
- large amounts of data can be checked/verified/accessed in a short period of time

Disadvantages include:

- could be hacked
- technology failures
- expensive to purchase
- requires IT maintenance
- needs internet connection
- cost of IT maintenance to prevent hacking / make sure data not lost
- need a lot of equipment/software

A6.4

Several pharmaceutical companies have been working collaboratively to use a universal software system to capture the data profiles of the different chemicals they store. Suggest why the companies have decided to use this software.

Indicative content

- to capture the data specific to storing chemicals across various organisations, help to keep track of the utilisation of these chemicals and demonstrate which ones are more commonly used
- to share information with other scientists/organisations working in similar fields
- to secure store commercially sensitive data
- to enable easy analysis and interpretation

A6.9

The results table below outlines the time (t) learners take to carry out a titration experiment.

Time (mins)	$0 < t \leq 10$	$10 < t \leq 20$	$20 < t \leq 30$	$30 < t \leq 40$	$40 < t \leq 50$
No. of learners	25	36	14	5	6

a) Estimate the mean from the data provided in the table, giving your answer to two decimal places.

b) Estimate the standard deviation from the data provided in the table.

Answer

a) Mean

Time (mins)	0<t≤10	11<t≤20	21<t≤30	30<t≤40	40<t≤50	
No. of learners (n)	25	36	14	5	6	Frequency = 86
Frequency x midpoint (mi)	25 x 5 = 125	36 x 15 = 540	14 x 25 = 350	5 x 35 = 175	6 x 45 = 270	Total = 1460
Mean = 1460/86 = 16.98						

b) Standard deviation

Range	Frequency (ni)	ni × mi	Mean (μ)	(mi-μ)	(mi-μ) ²	n×(mi-μ) ²
0<t≤10	25	25 x 5 = 125	Mean = 1460/86 = 16.98	5 - 16.98 = -11.98	143.52	3588
10<t≤20	36	36 x 15 = 540		15 - 16.98 = -1.98	3.92	141.12
20<t≤30	14	14 x 25 = 350		25 - 16.98 = 8.02	64.32	900.48
30<t≤40	5	5 x 35 = 175		35 - 16.98 = 18.02	324.72	1623.6
40<t≤50	6	6 x 45 = 270		45 - 16.98 = 28.02	785.12	4710.72
Total	86	1460				

Standard deviation

$$s = \sqrt{\frac{\sum(X - \bar{x})^2}{n - 1}}$$

X - The Value in the data distribution

$\bar{x}$ - The Sample Mean

n - Total Number of Observations

B1.16

A commercially available dye called soluble blue HT works as an inhibitor of DNA helicase. Apply your knowledge of enzymes and DNA replication to explain why this will reduce cells' ability to divide during mitosis.

Indicative content

- inhibitor blocks/changes shape of enzyme-active site
- enzyme no longer binds to DNA helicase
- no/few enzyme substrate complexes formed
- DNA helicase breaks H bonds (between DNA strands)
- DNA sequence cannot be copied / transcription prevented
- (semi-conservative) replication of DNA prevented
- no new DNA available for cell division/mitosis
- specific stage of mitosis fails

B2.1

Two different proteins contain the same amino acids but carry out different roles in the body. Apply your knowledge of protein structure and function to explain this.

Indicative content

- different order/sequence of amino acids **or** different primary structure
- hydrogen/ionic/disulphide bonds form in different positions
- different primary/tertiary/quaternary structure
- 3D shape
- structure linked to function / named example of protein and function, for example enzymes and haemoglobin

B2.21

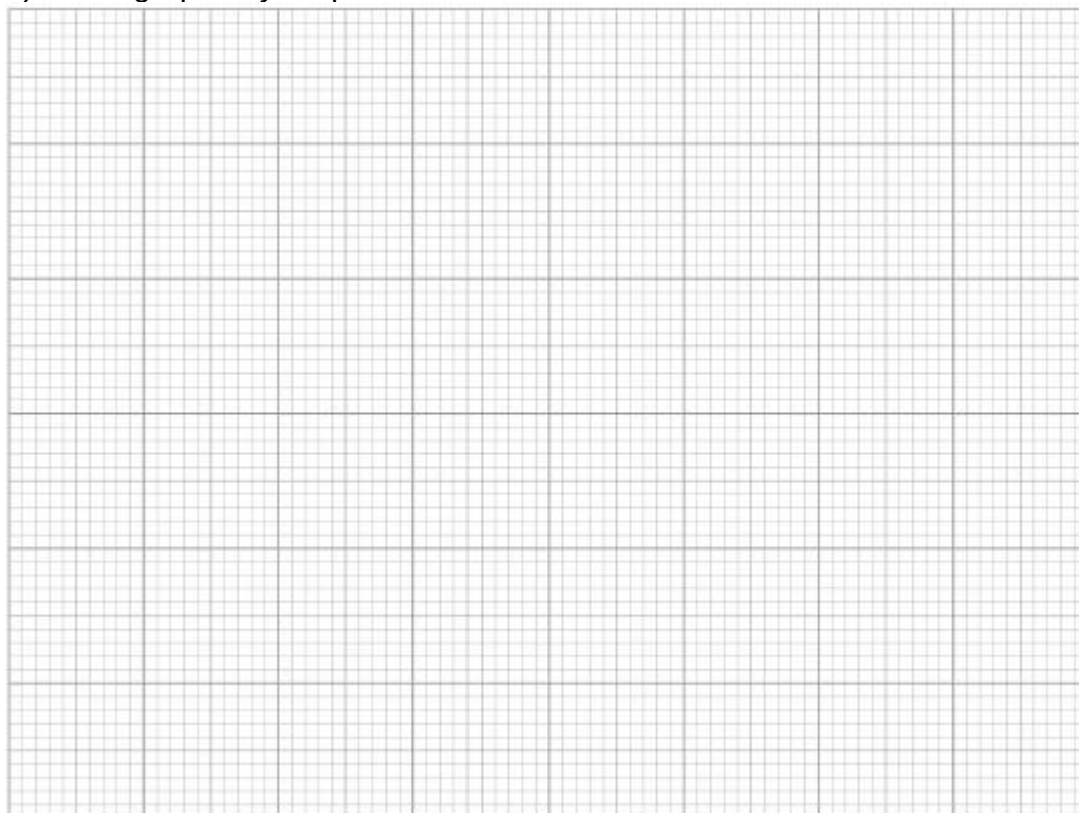
Hydrogen peroxide will break down into water and oxygen in the presence of a catalyst.

A learner carries out an experiment using potato chips that contain a catalyst called catalase to measure the time it takes to produce a fixed volume of oxygen from different concentrations of hydrogen peroxide. Their results are shown below:

Hydrogen peroxide concentration (mol dm ⁻³)	Time to produce 10cm ³ of oxygen (seconds)	Rate of reaction (arbitrary units)
0.5	20	
1.0	11	
1.5	8	
2.0	7	1.0
2.5	7	1.0

a) Complete the table by calculating the rates of reaction for each concentration to an appropriate number of significant figures.

b) Plot a graph of your processed data below.



c) Suggest one change that could be made to produce 10cm³ of oxygen in a faster time than seven seconds.

Answer

a) Table

Hydrogen peroxide concentration (mol dm ⁻³)	Time to produce 10cm ³ of oxygen (seconds)	Rate of reaction (arbitrary units)
0.5	20	0.35
1.0	11	0.64
1.5	8	0.88
2.0	7	1.0
2.5	7	1.0

b) Graph:

- hydrogen peroxide concentration on x-axis and rate of reaction on y-axis
- correct units (mol dm⁻³) and arbitrary units
- appropriate scale used
- correct plotting of points (not a bar chart)
- connected by a point-to-point or smooth line

c) Suggested changes:

- use more potato chips
- increase surface area of chips / cut them up smaller
- increase temperature
- change pH

B2.3

DNA strand	C	C	T	G	T	A	C	G	G	T	A	A
mRNA strand												

Explain how an error in this sequencing could lead to conditions such as cancer.

Indicative content

- DNA base sequence used for protein synthesis
- faulty/non-functioning proteins produced
- causes mutation
- causes error in cell cycle/division
- cancer caused by uncontrollable cell division

A10.6

Light microscopes are used to view a range of samples. Explain how to use a light microscope to correctly view a prepared slide of onion cells and measure the cell length.

Indicative content

- place slide on stage
- use lowest magnification lens to position cells in field of view
- use course/fine adjustment dials to increase resolution/focus
- change lens to increase magnification if necessary
- replace eyepiece lens with eyepiece graticule
- use graticule to measure multiple cell lengths and calculate average/mean
- calibrate eyepiece graticule using a stage micrometer
- use measurements to calculate individual cell length

B1.26 and B1.27

Smallpox is a disease caused by the variola virus and is estimated to have killed up to 300 million people in the 20th century. It was eradicated in the late 1970s following an intensive vaccination programme, using a vaccine originally developed by Edward Jenner in 1796.

a) Apply your understanding of virus transmission to suggest and explain how this disease was transmitted to such a large number of people.

b) Which populations or communities would have been most at risk and why?

c) Why might the existing vaccine no longer work if there was a future outbreak of smallpox?

Indicative content

a) Transmission:

- airborne – transmitted through coughs and sneezes
- physical contact – skin-to-skin contact with an infected person
- sexual contact – sexual contact with an infected person
- contaminated items – from unclean surfaces, for example, bedding/clothing
- unclean water / bite from vector

b) At risk populations:

- densely populated areas which increase the chance of contact with infected person
- lack of healthcare so less or no vaccinations/treatment options
- no health information so unaware of exposure risks

c) Vaccine efficacy:

- virus has mutated
- virus has developed resistance to vaccine
- vaccine antigens no longer complementary to pathogen

AO3 formative assessment material

A8

The figure below shows a SOP for preparing one batch of trypan blue stain.

Discuss the suitability of this SOP for achieving a standardised approach to the procedure.

Trypan Blue Staining

Materials

- 2 x Trypan Blue stain.
 1. 60 ml Lactic acid (Sigma L-1250)
 2. 60g Phenol
 3. 60ml 100% Glycerol
 4. 60 ml dH₂O
 5. 60mg Trypan blue
- Chloral hydrate de-stain solution.
 1. 25g Chloral hydrate
 2. 10ml dH₂O

Method

1. Dilute Trypan Blue stain solution 1:2 with ethanol before use
2. Immerse leaf samples in trypan blue stain solution.
3. Place bottles in a pan of boiling water.
4. Leave bottles in the pan until the stain in the bottle also boils. Let sit for 3 mins.
5. Take the pan off the heat, with the bottles still inside and leave to cool in pot for 1 hours (30 min).
6. Transfer samples to de-stain solution and view the next day.
7. Mount in water or 50% glycerol.

Notes
Leaves can be cleared before Trypan Blue staining to remove chlorophyll and other pigments.

Indicative content

A SOP is a set of sequential steps or instructions designed to standardise the approach to a process or action.

It is important for everyone to follow SOPs in order to maintain health and safety through:

- enabling consistency of approach
- meeting any legal or organisational requirements
- upholding professional standards
- demonstrating compliance for audit purposes

Positives:

- volumes of solutions and solids indicated
- volumes and specific named chemicals enables consistent approach
- legal requirements met by including named chemicals that link to COSHH
- sequential steps enable upholding professional standards
- reagents named
- sequence of steps for method are brief and easy to understand and follow
- disposal details would prevent damage to the environment caused by waste being disposed of down a drain
- specific named equipment enables staff to follow sequential steps

Negatives:

- some items of equipment are not named
- version update not included
- disposal details not included
- dates should be added to SOPs to enable laboratory audit processes

B1.33

Every year, around eight million tons of plastic waste flows into the ocean from coastal nations.

Polymer	Flame resistance	Saltwater resistance	Sunlight resistance	Strength/toughness
Natural rubber	E	A	B	D
Silicone elastomer	B	A	B	D
Nylon	C	A	C	C
Polycarbonate	B	A	B	C
Acrylic	D	A	A	C
Polystyrene	D	A	C	B
Polyester	D	A	A	C
Rigid polymer foam	E	A	C	B

Key: A–E where

A = highest resistance / greatest strength/toughness

E = lowest resistance / least strength/toughness

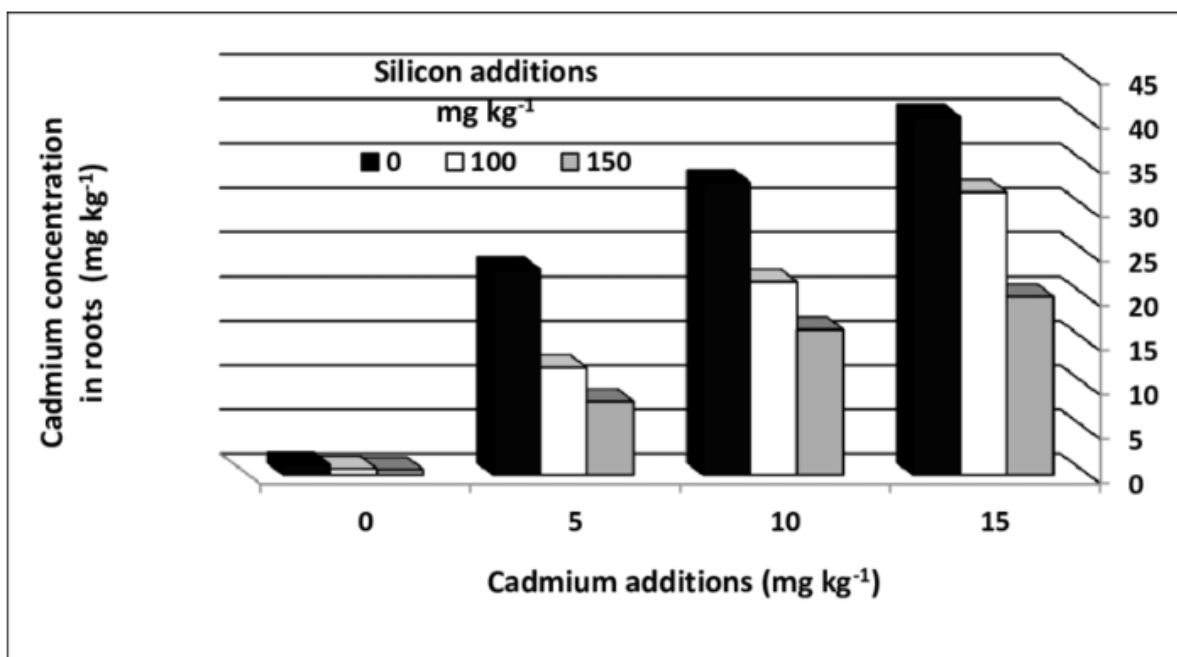
Analyse the information provided in the table above to determine the different levels of impact that different polymers have on the ocean ecosystem.

Indicative content

- structure – long chain molecules with forces or bonds between the chains
- properties – strong, chemically unreactive, electrical insulators
- unreactive so reacts slowly in the environment
- flammability – if flammable could be disposed of by incineration. for example, Butyl rubber or rubber.
- freshwater – reactions may occur which enable separation at a waste disposal centre or in rivers before reaching the ocean although all polymers are resistant to water.
- saltwater – reaction may occur which cause plastics to break down into microplastics in the ocean, leading to accumulation in the food chain / tissues of animals although all polymers are resistant to seawater
- UV – those most resistant will stay intact and may risk choking animals, for example PVC, acrylic, while those not resistant may breakdown in sunlight and spread over a wide area as microplastics
- wear resistance – damage during transport, most resistant will remain strong and in one piece
- consider balance between the most resistant polymers that will stay intact and build up on beaches and in reefs, affecting the natural ecosystems
- some plastics readily break down, generating microplastics
- considers which properties lead to increased recycling and reusing

A6.6

Analytical chemists at an agrochemical firm working on brownfield sites are investigating how cadmium (a toxic metal) accumulates in the roots of lettuce plants. The figure below displays the results of the investigation.



The chemists' hypothesis is that adding silicon to the soil reduces the cadmium concentration in the lettuce roots.

To reduce errors in scientific settings laboratory technicians use control variables, correctly store materials and automate processes.

Discuss how each of these measures may be challenging for this investigation.

Indicative content

- minimise errors by controlling as many variables as possible other than those being investigated – when outside the weather and the open system make it impossible to control all variables
- variation in temperature may cause reactions/evaporation to be faster during the investigation
- plant quality may be impacted by a change in temperature, for example, leaves wilting
- variation in rainfall may increase the flow of cadmium away from the roots
- stored materials may need to be transported to site regularly to carry out the investigation
- access to temperature-controlled/secure storage provision may be limited at the site
- automated processes are more difficult to set up on site due to uncontrolled conditions, access to electricity and security, non-automated processes will

instead require large numbers of staff which may result in inconsistency of results

A4

A NHS pathology laboratory has a critical role in the care of patients as it is involved in 70 per cent of the hospital's diagnosis decisions. The laboratory runs 24 hours a day and usually has a staff handover time when one shift finishes and another begins.

One day staff shortages meant that only one technician was present. They needed to leave early because of an emergency, leaving no possibility of a handover. The technician coming on shift had recently joined the team and had completed the laboratory induction programme. The technician considered their options about how to start the shift, which are outlined below.

Option one: spend the first four hours of the shift sterilising all equipment left out in the laboratory using the autoclave and disinfect all surfaces – this may have been completed at the end of the previous shift but without the handover there is no certainty.

Option two: start testing the samples from all over the hospital which are building up – otherwise, the clinical staff will be delayed which will further impact the huge demand for hospital beds.

Option three: check the staff contact list for other technicians and call in some additional staff – with more staff the sample test rate will be higher.

Discuss the risks and benefits of each of the three options. Conclude your discussion by stating which would be the most suitable approach, giving reasons for your decision.

Indicative content

Key principles

Biohazard risk:

- risk of infection to employee
- risk of infection to team working at laboratory
- risk to patients/staff in hospital
- risk of spreading disease to the wider population

Contaminant treatment:

- sterilisation
- disinfection
- incineration

Option 1: Manages biohazard risk to reduce risk of infection to staff and reduce cross contamination risk in the laboratory. Autoclaving and sterilising kill any pathogens and reduce the risk of cross contamination. The delay in testing may lengthen diagnosis time, which may increase risk of spreading disease.

Option 2: Without handover there is a risk of cross contamination from dirty equipment. This may result in an incorrect diagnosis with consequences for patients. There is a risk that staff using the equipment may be exposed to biohazards.

Option 3: Allowing time to clean and decontaminate will reduce risk of biohazards. Tests will be carried out at higher rate so patients will receive results more quickly.

Evaluation / reasoned judgement / conclusions

- consider how to improve this situation by maintaining records in labs for all cleaning procedures
- reflect on loan-working procedure – if only one person is available consider sending samples to alternative sites and closing labs
- adapt training procedures so that staff are aware of procedures to follow for every scenario
- consider the balance between data required by medical staff and maintaining the quality of the lab – risks of cross contamination could lead to staff infection and absence and impact the wider population

A4.18

At a national food allergy testing laboratory, food samples are tested to confirm the nutrients present and the concentrations at which they occur. Technicians select the most suitable testing methods depending on the outcomes they need and the hazards associated with the test. They are reviewing the methods used to test for proteins and need to select from the four tests below.

Millon's reagent Used to test for proteins <i>and</i> Cole's modification (Millon's reagent A)	 TOXIC  HEALTH HAZARD  CORROSIVE  ENVIRON.	DANGER: It contains a high concentration of a mercury compound and concentrated nitric acid (see CLEAPSS <i>Student Safety Sheets</i> 21 and 44). Cole's modification is less hazardous because it contains less concentrated sulfuric acid and also uses sodium nitrate(III) (nitrite). DANGER: Fatal if swallowed or on skin contact; causes severe skin burns and eye damage; suspected of causes genetic defects and damaging fertility. Because of toxicity, all residues must be collected for licensed disposal. There is a risk of spitting when it is heated in a test tube.
Sakaguchi test Used to test for proteins	 CORROSIVE  HIGHLY FLAMMABLE  ENVIRONMENT	The test involves mixing three solutions: sodium hydroxide (~1.3 M), naphthalen-1-ol in ethanol (~0.07 M) and sodium chlorate(I) (hypochlorite) (~ 1.5 M). See relevant CLEAPSS <i>Student Safety Sheets</i> . Despite these hazards, it is safer to use than either form of Millon's reagent because it does not need to be heated and only a few drops are required. The biuret test is safer still (see CLEAPSS <i>Student Safety Sheet</i> 4). DANGER: corrosive to skin and eyes, highly flammable
Albustix Used to test for proteins	LOW HAZARD	This will not detect all proteins. It is normally used for testing urine.
Biuret test Used to test for proteins	 CORROSIVE	See CLEAPSS <i>Student Safety Sheets</i> 31 and 40. DANGER/WARNING: The very dilute copper sulfate solution is LOW HAZARD. Sodium hydroxide solution may be CORROSIVE, IRRITANT or LOW HAZARD depending on concentration.

Discuss the suitability of the four methods of testing for proteins. Conclude your answer by selecting the most suitable method to use, briefly justifying your choice.

Indicative content

I

Albustix:

Advantages – quick (as on a stick), therefore easy to test on site; low hazard so limited PPE required and limited training needed; straightforward disposal.

Disadvantages – not suitable to use with all proteins.

Biuret test:

Advantages – meets requirements as used to test for proteins; although sodium hydroxide may be corrosive it can be used at lower concentrations to reduce risk.

Disadvantages – sodium hydroxide may be corrosive at higher concentrations so could burn body tissue and severely damage eyes; need high quality PPE.

Sakaguchi test:

Advantages – although hazards are associated with this test only a small amount of mixed solution is required, which reduces risk as spillages are less likely; reduced risk of contact with skin as less solution is used; no heating required so will not create vapour.

A7

Before bringing a new e-cigarette to market the manufacturer must carry out a clinical trial. The company involved 100 participants in a four-week trial. Half of the participants were asked to use the new e-cigarette and the other half were asked to continue using their regular e-cigarette. The researchers knew which participants were using the new e-cigarette. No restriction was placed on how often participants could use the e-cigarette each day.

Assess whether the structure of this trial would lead to a reliable conclusion about the new e-cigarette's effect on nicotine dependency.

Indicative content

- only 100 participants in the trial: not sufficient to generate reliable results
- only a four-week trial: not long enough to generate valid results
- half of the participants were using their own e-cigarettes: there was no monitoring of these or their nicotine content
- researchers and participants knew which participants were using which e-cigarette: the trial was not double-blind which could introduce bias / affect validity of results
- no monitoring of how often the e-cigarettes were used: results from the two groups would not be comparable

A6

Two research scientists have investigated the effect of pH on amylase activity. The table below shows results of their experiment.

- a) Calculate the rate of breakdown of starch and record your answers in the column provided.

pH	Time taken for disappearance of starch (s)	Rate of breakdown of starch (1/t)
5	120	
6	40	
7	30	
8	50	
9	150	

- b) Explain the effect of pH on amylase activity, using a graph to support your explanation.
- c) Evaluate the results and explain how the two research scientists could minimise the errors in their investigations.

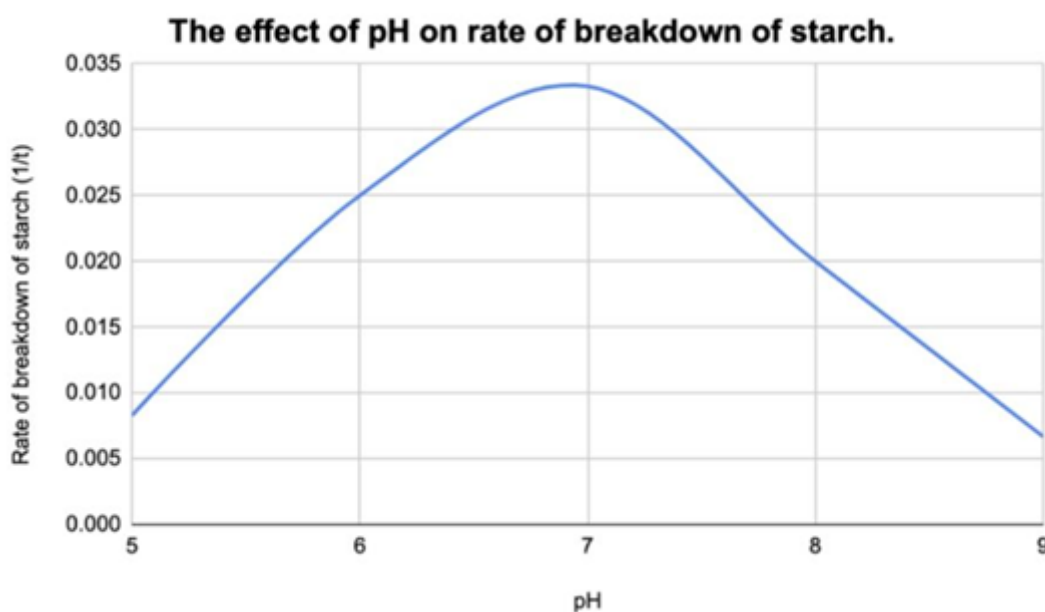
Answer

a)

pH	Time taken for disappearance of starch (s)	Rate of breakdown of starch (1/t)
5	120	0.0083
6	40	0.0250
7	30	0.0333
8	50	0.0200
9	150	0.0067

Indicative content

b) Sample graph



- The reaction will be the fastest at a specific pH. This is known as the optimum pH for the enzyme.
- The reaction is slower when the pH value is above or below this point.
- The pH affects enzyme reactions because it affects the detailed structure of the active site of the enzyme.
- If the shape of the active site changes, that will alter its effectiveness as a catalyst.

Indicative content

c) Minimising errors:

- using controlled variables
- staff training and monitoring
- maintenance and calibration of equipment
- correctly storing materials
- using automated processes
- good experimental planning

A6.6

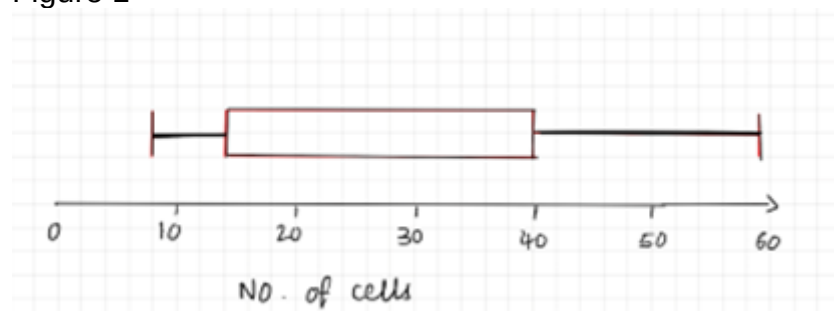
Scientist A and scientist B have investigated the number of cancerous cells in five different samples.

Scientist A has produced a results table (Table 1) while scientist B has produced a box plot of results (Figure 1).

Table 1

Minimum	Lower quartile (LQ)	Median	Upper quartile (UQ)	Maximum
13	26	34	42	56

Figure 1

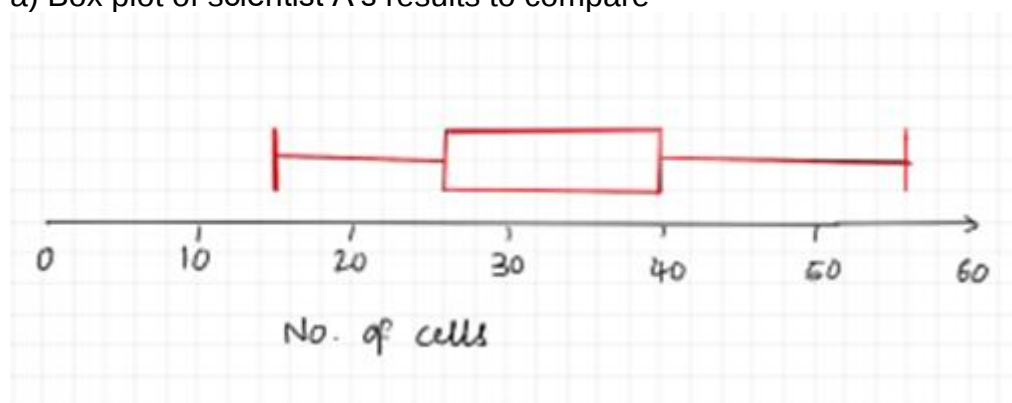


a) Compare the distribution of the number of cells found in scientist A's data with the distribution of the number of cells found in scientist B's data.

b) Using the results from the two scientists suggest possible reasons why there are discrepancies in the data.

Indicative content

a) Box plot of scientist A's results to compare



$$\text{A: UQ-LQ} = 40 - 26 = 16$$

$$\text{B: UQ-LQ} = 40 - 16 = 24$$

Scientist A's interquartile range of scientist A is lower, suggesting that the data are less spread out.

b) Reasons for discrepancies:

- type of sampling used by each scientist may have been different
- use of different equipment and handling it differently through the procedure may have created room for error
- lack of replication of experiments to produce consistent results

A6.9

A high number of infectious disease cases have been reported at a pharmaceutical company over the last six months. To investigate this the company has carried out an evaluation of the concentration of airborne agents in the building, for which they have data for the last 10 months. They have also collected data on the number of employees affected by infectious diseases over the same time period. The results are shown in the table below.

Month	Airborne agent concentration (percentage)	No. of infections
1	18.4	3
2	19.5	2
3	19.9	1
4	20.5	6
5	21.3	4
6	23.1	5
7	23.6	9
8	24.9	10
9	26.6	7
10	29.2	8

- a) Using statistical analysis, evaluate the strength of the correlation of the results.
- b) Suggest measures that could be taken by the pharmaceutical company to mitigate the risk of transmission of airborne agents.

Indicative content

- a) Results of the calculation of Spearman's rank correlation coefficient

Month	Airborne agent concentration (percentage)	Rank of airborne agent concentration (percentage)	No. of infections	Rank of no. of infectious diseases	d	d ²
1	18.4	3	3	10	7	49
2	19.5	2	2	9	7	49
3	19.9	1	1	8	7	49
4	20.5	6	6	7	1	1
5	21.3	4	4	6	2	4
6	23.1	5	5	5	0	0
7	23.6	9	9	4	5	25
8	24.9	10	10	3	7	49
9	26.6	7	7	2	5	25
10	29.2	8	8	1	7	49
Total						300
$r_s = \frac{6\sum di^2}{n - (n^2 - 1)} = \frac{6(300)}{10(10^2 - 1)} = -0.818$						

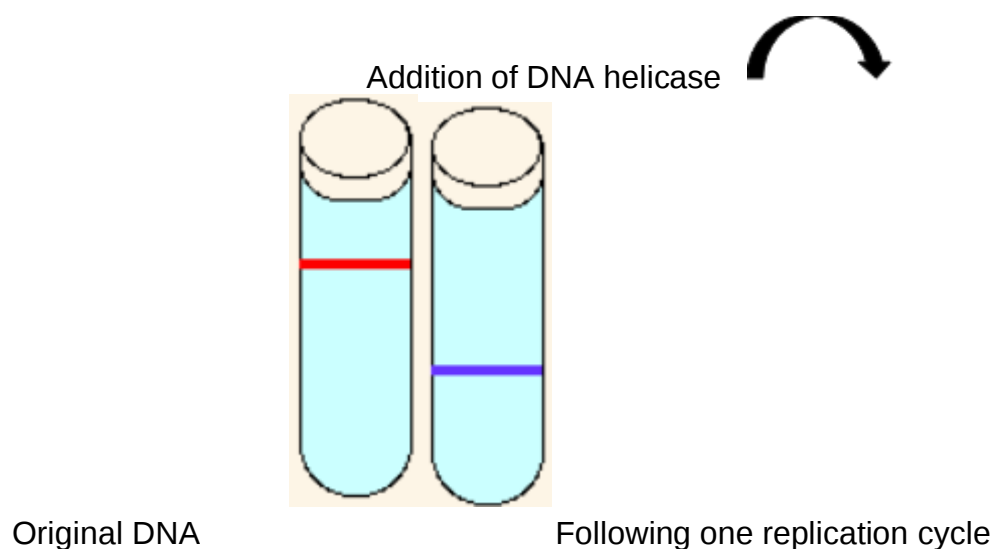
There is a negative correlation between the concentration of the airborne agents and the number of infectious diseases reported. The results demonstrate that a higher

rate of infections was reported when the concentration of airborne agents in the building was high.

b) Measures that could be taken to mitigate the risk of transmission:

- health and safety risk assessment
- awareness of hygiene in the workplace, for example through posters
- health and safety training provided to all staff

B1.16



An investigation was carried out on DNA replication. During the investigation DNA strands were added to a test tube solution containing individual DNA nucleotides, which included bases with a denser form of nitrogen. DNA helicase was then added to the solution. The results are shown in the diagram above.

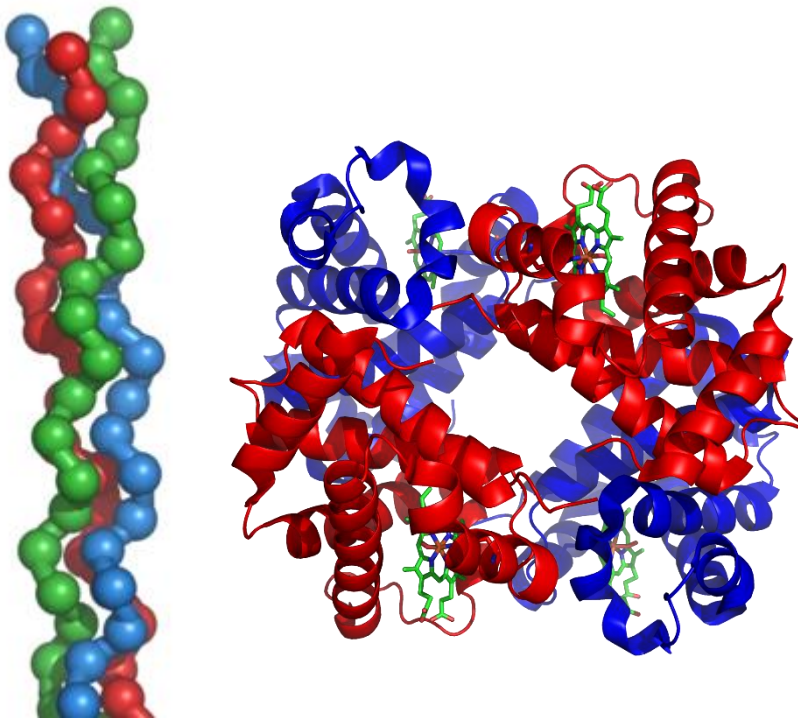
Explain the results.

Indicative content

- semi-conservative replication process
- DNA helicase breaks H bonds between strands
- each strand can act as a template for new strands
- DNA polymerase joins new DNA nucleotides / forms new strand

- each new strand produced contains DNA nucleotides containing the denser nitrogen
- new DNA double helix contains one old and one new strand
- new DNA strand is denser and sits lower in the test tube

B2.1



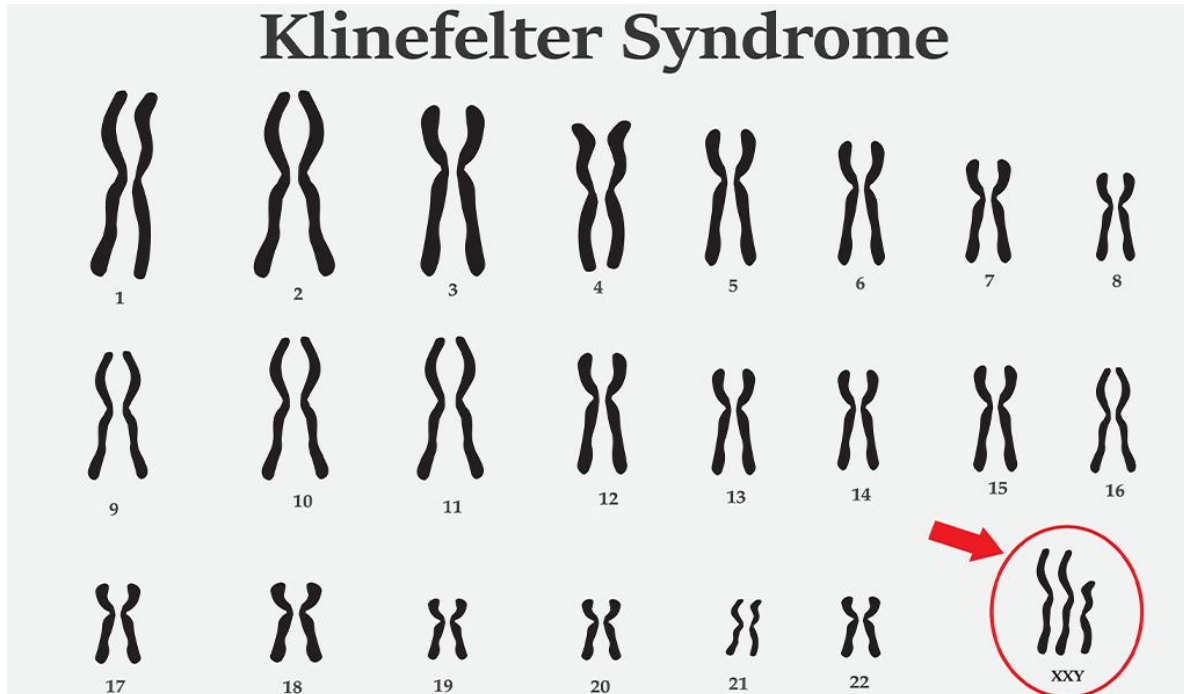
The diagrams above represent proteins that can be found in the human body. Suggest which functions these proteins could carry out and why.

Indicative content

- tertiary/quaternary structure
- correct description of fibrous, for example, structural or strength, water soluble
- correct description of globular, for example, transport, soluble, immune response, cell signalling
- named example of fibrous, for example, collagen, keratin, elastin

- named example of globular, for example, haemoglobin, insulin, amylase

B2.9



Klinefelter syndrome is a genetic condition that produces an extra copy of the X chromosome in male offspring which subsequently affects their sexual development during puberty. Discuss how cases of Klinefelter syndrome occur.

Indicative content

- both copies of the X chromosome are passed into the egg cell / zygote / fertilized egg
- extra copy occurring second division of meiosis
- copies of X chromosome are not separated during anaphase/second stage of meiosis
- error in stages of cell division, for example, spindles not attaching/contracting correctly
- mitosis passes on condition in genetically identical daughter cells

B2.3

Scientists have discovered an enzyme that inhibits the production of “protein X” by animal cells. They have also identified the gene in the cells’ DNA responsible for the coding of protein X. Scientists refer to this gene as gene X.

In an experiment, scientists measured the amount of gene X, mRNA X, tRNA X and protein X in cells exposed to the enzyme. They also ran a control sample of cells that were not exposed to the enzyme. The results are shown in the table below.

Test group	Mass of gene X per cell (ng)	Mass of mRNA X per cell (ng)	Mass of tRNA X per cell (ng)	Mass of protein X per cell (ng)
Exposed to enzyme	18.5	7.6	11.1	0.8
Control (not exposed to enzyme)	19.1	7.5	10.9	12.1

Using the information above explain how the enzyme could be inhibiting the production of protein X.

Indicative content

- transcription is unaffected by the enzyme: mRNA X production is unaffected
- tRNA is not broken down by the enzyme: mass of tRNA X is unaffected by the enzyme
- DNA is not broken down by the enzyme: mass of gene X is not affected by the enzyme

The enzyme could be:

- inhibiting the ability of mRNA to exit the nucleus – if mRNA cannot enter the cytoplasm and reach ribosomes, translation will not occur
- breaking down / inhibiting the function of ribosomes – ribosomes assemble tRNA-carrying amino acids to form the primary structure of the protein
- be inhibiting further stages of protein synthesis in the endoplasmic reticulum (ER) or Golgi body – the ER and Golgi body are responsible for producing the secondary, tertiary and quaternary structure of the protein

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