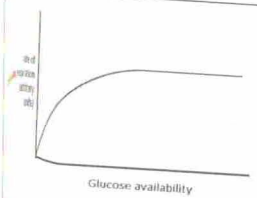
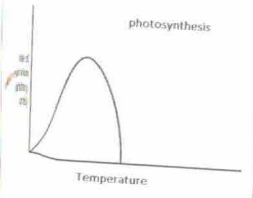
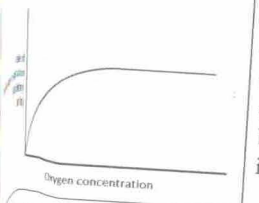
glucose → carbon dioxide + alcohol + 2ATP

Aerobic respiration is more efficient as the glucose molecule is broken down to simple inorganic materials, carbon dioxide and water, and the maximum amount of energy is extracted – enough to make 36 molecules of ATP. Anaerobic respiration represents the partial breakdown of a glucose molecule to alcohol and lactic acid (still large molecules) and releases only enough energy to make 2 molecules of ATP.

Respiration can be thought of as photosynthesis in reverse. The reactants of one reaction are the products of the other! They are different in terms of energy. Respiration is an exergonic reaction. Photosynthesis is an endergonic reaction.

A double membrane surrounds both mitochondria and chloroplasts, and both contain DNA and RNA similar to that found in bacteria.

Factor affecting photosynthesis	Explanation
	As glucose is a reactant in cellular respiration, increasing its concentration will increase the rate of reaction until the enzymes are operating at full capacity or oxygen concentration has become a limiting factor.
	As temperature increase the kinetic energy of the reactants in cellular respiration and enzymes increase resulting in increased rate of cellular respiration. After optimal temperature is reached the enzymes involved in cellular respiration denature resulting in a decrease in rate.
	As oxygen is a reactant in aerobic respiration, increasing its concentration will increase the rate of overall cellular respiration until the enzymes are operating at full capacity or availability of glucose has become a limiting factor. Note that oxygen is not a reactant in anaerobic respiration.

CRISPR-Cas 9 technology allows scientists to make precise changes to a plant's genome. This means genes that improve photosynthetic efficiency and crop yields can be inserted in o the genome of plant crops and those genes that reduce photosynthetic efficiency and crop yields can be deactivated or deleted. For example, Yield 10 is developing crops of canola and soybean with improved oil content and that are drought tolerant.

Biomass is renewable organic material that comes from plants and animals. Biofuel refers to a fuel that is produced by the anaerobic fermentation of biomass.

When yeast respire anaerobically, glucose is broken down to ethanol, carbon dioxide and two molecules of ATP. Biomass can be used as a source of glucose for aerobic respiration. The ethanol produced can be used as a fuel.

Chapter 3: Multiple-choice questions

3-47 [VCAA 2015 SA Q6]
Which one of the following is the substrate in this reaction?
B starch. (Starch is broken down by amylase in the solution and is therefore the substrate. Maltose is the product.)

3-48 [VCAA 2013 E1 SA Q8]
Based on the information in the graph, a correct conclusion would be that
A this is an anabolic reaction. (The products of anabolic/build-up reactions store more energy than the reactants as shown by the higher energy level of T and U. The reaction requires energy and the activation energy is the energy required to start the reaction.)

3-49 [VCAA 2011 E1 SA Q23]
From the two graphs, it is reasonable to conclude that
D energy is released in reaction P only. (In Reaction P the energy of products is lower than the energy of the reactants; therefore, energy has been released. The activation energy of reaction M is actually less than that of P. M is an endothermic reaction whereas reaction P is an exothermic reaction.)

3-50 [VCAA 2020 SA Q4]
Test tube 3 will
C decrease due to competitive reversible inhibition by Substrate B. (Substrate B competes with Substrate A for the enzymes active site; therefore, less active sites are available to Substrate A so less product will be produced. The results for test tube 2 indicate that Substrate B is a reversible inhibitor.)

3-51 [VCAA 2020 SA Q13]
It is reasonable to conclude that
D the optimum temperature for Celluclast® is around 57 °C. (At 61°C Celluclast is still active but less active than at 57°C. At 35 °C the lack of activity is due to low temperature rather than denaturing. There is no information on pH.)

3-52 [VCAA 2020 SA Q14]
The error bars on the graph indicate that the measurements taken at
B 52 °C were more precise than at 46 °C. (The smaller the length of the error bars the greater the accuracy. Note that 52 °C the error bar is narrower than at 46 °C.)

3-53 [VCAA 2018 SA Q7]
Which student correctly identified all four variables on the horizontal axes?
D Sheena (Variable 1 has to be temperature – activity rises to maximum before the enzyme is denatured. Enzymes usually have a pH optimum, as pH rises activity increases to the optimum then drops off. For variables 3 and 4 – rate of reaction rises to a maximum – additional enzyme or substrate do not cause a further increase.)

3-54 [VCAA 2017 SA Q6]
An explanation for the results of Test 2 would be that the student
C used a hydrogen peroxide solution with a higher concentration. (The graph shows an increase in the volume of oxygen produced, i.e. an increase in the amount of final product. Increasing temperature and amount of enzyme will not increase the amount of final product but increasing the initial amount of substrate will.)

3-55 [VCAA 2017 SA Q7]
It is expected that
C at pH 2 and pH 10 very little oxygen will be produced. (Extremes of pH denature enzymes therefore the reaction will only occur slowly. pH 6 is close to the optimum pH of 7 therefore the reaction will occur to some extent.)

3-56 [VCAA 2017 SA Q8]
The reason the student calibrated the pH meter was to
D allow the pH to be measured accurately. (Accuracy refers to how close a measurement is to the true value or standard whereas precision refers to how closely two or more measurements agree. Measurements may be precise but inaccurate.)

3-57 [VCAA 2014 SA Q13]
Which one of the following statements about the activity of the four enzymes is true?
C At pH 3 and a temperature of 37 °C, the active site of enzyme W binds well with its substrate. (Enzymes are not denatured by low temperatures. The optimal temperature for Z is 75°C therefore, it is unlikely to be from the human body where the temperature is 37°C. Enzyme X optimum is at pH 7.)

3-58 [VCAA 2012 E1 SA Q2]
The activity of an enzyme is
A decreased by the presence of an inhibitor. (Enzymes are denatured by high temperatures and have an optimum pH for activity.)

3-59 [VCAA 2011 E1 SA Q16]
From these graphs it is reasonable to infer that at a pH of 4
D lysozyme has the highest activity of the three enzymes. (Looking at the graphs at pH 4 lysozyme is just about at the optimum pH activity. In all other cases the statement is incorrect or there is insufficient information to make a conclusion.)

3-60 [VCAA 2011 E1 SA Q22]
It is likely that in Melbourne
D Siamese cats that live outside in winter have darker fur than Siamese cats in tropical regions. (You need to have realised that while the core temperature might be constant and above 37°C. No matter what the external temperature is, the temperature of extremities, such as the tail and ears, may be cooler than 37°C and therefore pigment may be produced.)

3-61 [VCAA 2018 SA Q10]
Which pair of molecules contains the greatest amount of stored energy?
A NADH and ATP (These are the largest molecules and contain the biggest stores of chemical energy. Consider alternative D – ADP is converted to ATP with the addition of a free phosphate molecule and energy.)

3-62 [VCAA 2017 SA Q16]
It is correct to state that
D $NADP^+$ carries additional energy when protons and electrons are added to it. ($NADP^+$ becomes NADPH not NADH. Loaded NADPH has a higher energy level and energy is released when NADPH is converted to $NADP^+$.)

3-63 [VCAA 2016 SA Q9]
ATP is important in living cells as it
B. provides a supply of usable energy for the cell. (ATP is the immediate source of energy for cellular activity. Osmosis is a passive process not requiring energy, ATP is not a component of lipids or plasma membranes.)

3-64 [VCAA 2015 SA Q7]
The production of ATP
B requires an overall input of energy. (The reaction is a synthesis reaction – building bigger molecules – therefore requires an energy input. ATP is also produced in anaerobic respiration, which occurs in the cytoplasm.)

3-65 [VCAA 2016 SA Q16]
Which one of the following is a catabolic process?
A the conversion of glycogen to glucose (Catabolic processes involve a release of energy. The other three processes are synthesis reactions and require an energy input.)

3-66 [VCAA 2020 SA Q9]
The dependent variable in this experiment is the
B number of bubbles produced in one minute. (The dependent variable is what the scientist measures. In this example, the number of bubbles produced in one minute is measured by the scientist.)

3-67 [VCAA 2020 SA Q10]
The bubbles produced in this experiment are likely to contain
A oxygen. (The process that is occurring is photosynthesis. The bubbles of gas will be oxygen a product of photosynthesis.)

3-68 [VCAA 2020 SA Q11]
Repeating the experiment three times and finding an average result at each distance increases the
A reliability of the data. (By repeating the experiment, the scientist is looking for consistency in results. If repeating the experiment under the same conditions yields similar or consistent results, the results can be seen as reliable.)

3-69 [VCAA 2020 SA Q12]
During photosynthesis
C ATP and NADPH are created in the grana of the chloroplasts and are used in the light-independent stage. (Facts. D is incorrect as the Krebs cycle is part of respiration – not photosynthesis. ATP and NADPH are produced in the light-dependent reactions that occur in the grana that are necessary for the light-independent reactions.)

3-70 [VCAA 2020 SA Q33]
Which one of the following could be a correct statement about the qualitative data obtained by the student?
D The data could be the names of the different colours of the reflected light. (The keyword is qualitative data – that is descriptive data – not numerical or quantitative data. The only alternative that involves qualitative data is D.)

3-71 [VCAA 2017 SA Q15]
From this information, it can be concluded that
D glucose would be manufactured from carbon dioxide and water in cells from section M but not in cells from section K. (Cell K lacks chloroplasts therefore chlorophyll is not present and the light-dependent reactions and following light-independent reactions cannot occur. Cell K has mitochondria therefore the cell is able to aerobically respire. Cell M has chloroplasts therefore it can photosynthesise.)

3-72 [VCAA 2014 SA Q7]
During photosynthesis in chloroplasts, energy is used to split water, forming oxygen and hydrogen ions. The splitting of water occurs
B in the grana during the light-dependent reaction. (The stroma is the site of the light-independent reactions, but this is not where water is split. The light-dependent reactions occur on the thylakoid membranes of the grana.)

3-73 [VCAA 2016 SA Q10]
Which one of the following would contain the radioactive oxygen atoms after four hours?
C oxygen gas (As a plant photosynthesises it uses water.)

3-74 [VCAA 2016 SA Q11]

Which one of the following statements about photosynthesis in chloroplasts is correct?

C The light-dependent stage produces ATP for use during the light-independent stage. (A detailed understanding of the inputs and outputs of all stages of photosynthesis is required. Light energy is the input required to make ATP a source of energy available at all times. Chlorophyll is found in the grana rather than the stoma.)

3-75 [VCAA 2014 SA Q8]

The rate of photosynthesis increases because

D the rate of the light-independent reactions in the stroma increases with the increase in CO_2 level. (CO_2 is an input to the Calvin cycle, which is part of the light-independent reactions, which occur in the stroma.)

3-76 [Adapted VCAA 2012 E1 SA Q22]

The process that produces the largest number of ATP molecules is

D the electron transport chain in cellular respiration. (Fact. Synthesis requires the conversion of ATP to ADP; glycolysis and the light-independent reactions produce only a small amount of ATP.)

3-77 [VCAA 2018 SA Q14]

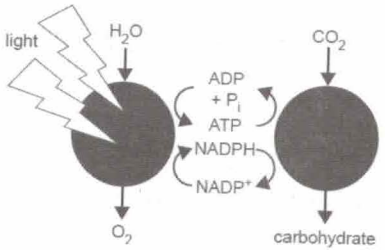
The light-independent reaction of photosynthesis occurs at

B U. (U is the matrix of the chloroplast and is the site of the light-independent reactions. The light-dependent reactions occur at R – the grana.)

3-78 [VCAA 2018 SA Q15]

Which one of the following diagrams correctly represents the inputs and outputs of photosynthesis?

B.



(**D** is incorrect because CO_2 is not split in the light-dependent reaction. **A** is incorrect – it should be NADPH and NADP+ rather than NADH and NAD+. **C** and **B** are nearly identical but note the direction of arrows in ATP production – as carbohydrate is produced ATP is broken down – hence **B** is correct.)

3-79 [VCAA 2019 SA Q15]

Based on your knowledge and the information in the graph, which one of the following conclusions can be reached?

C Light intensity is a limiting factor when the photosynthetic rate is less than 40 arbitrary units. (Based on the information given provided, light is a limiting factor up to 12 arbitrary units for light – graph levels off – photosynthetic rate then is constant at 40 arbitrary units. B is incorrect because some photosynthesis is occurring at 1 arbitrary unit. No information is given for changes in carbon dioxide level.)

3-80 [VCAA 2017 SA Q13]

Which one of the following conclusions can be made based on the graph?

D Below 10 AU of light intensity the aerobic respiration rate is greater than the photosynthesis rate. (Photosynthesis occurs as soon as the light is turned on. At point T oxygen output from photosynthesis equals the oxygen input for aerobic respiration. The graph levels off at 50AU rather than 40AU.)

3-81 [VCAA 2017 SA Q14]

The rate of oxygen output remains constant between points P and O because

B the concentration of available carbon dioxide limits the rate of photosynthesis. (If the enzymes are denatured or chlorophyll damaged the graph would not level off, rather the net output of oxygen would dramatically decrease.)

3-82 [VCAA 2020 SA Q5]

Which one of the following is a correct statement?

D NADH created in Pathway 2 carries electrons into the electron transport chain. (The biochemical process shown in the diagram is respiration. Pathway 1 is anaerobic respiration and Pathway 2 is aerobic respiration. Carbon dioxide is an output of respiration, not an input and oxygen is an input to aerobic respiration. The electron transport chain is the final step in aerobic respiration.)

3-83 [VCAA 2020 SA Q6]

The final products of Pathway 1 are produced in the

B cytosol. (The pathway represents anaerobic respiration which occurs in the cytoplasm rather than the mitochondria.)

3-84 [VCAA 2017 SA Q5]

It is correct to state that, in this reaction, phosphofructokinase

B increases the rate of reaction. (Phosphofructokinase is an enzyme; therefore, it increases the rate of the reaction. Fructose 6-phosphate is the substrate.)

3-85 [VCAA 2019 SA Q14]

In glycolysis, the ATP yield per molecule of glucose is

A 4 ATP produced, and 2 ATP used for a net gain of 2 ATP. (Glycolysis is the first step in cellular respiration and results in a net gain of ATP, therefore A is correct and B incorrect. In the complete breakdown of a glucose molecule, there is a net gain of 36 to 38 ATP.)

3-86 [VCAA 2019 SA Q7]

Which one of the following hypotheses is supported by the results?

D If the temperature increases, then the bacteria will grow more quickly. (Using the information given, D is supported by the results. Going from –10°C to 25°C there is an increase in the percentage cover of agar from 0% to 60% over 4 days.)

3-87 [VCAA 2019 SA Q8]

In this experiment, the dependent variable is

D the percentage of nutrient agar covered by bacteria. (The dependent variable in an experiment is the factor being measured – in this case % agar covered by algae. Temperature is an independent variable and time is the same for all setups.)

3-88 [VCAA 2019 SA Q9]

The students wanted to check the reliability of their data.

The students should

A repeat the experiment several times to find out if they would obtain the same data. (If the data is reliable, repeating the experiment should yield similar results. Rewriting the method or changing format will not affect reliability. Changing the independent variable results in a different experiment.)

3-89 [VCAA 2018 SA Q8]

The sites of the pathways in aerobic respiration are

C R – glycolysis, U – Krebs cycle, T – electron transport chain. (Glycolysis occurs in the cytoplasm, so the answer is one of A or C. Krebs cycle occurs in the mitochondrial matrix (U) and the electron transport membrane occurs in the membrane of mitochondria (T).)

3-90 [VCAA 2018 SA Q9]
Which of the following gives the inputs and outputs of the electron transport chain in an animal cell?

	Inputs	Outputs
A	NADH, ADP, oxygen, P_i	ATP, NAD^+, water

(Fact)

3-91 [VCAA 2017 SA Q11]
After this time, the radioactively labelled oxygen atoms would be present in which cellular chemical?

3-92 [VCAA 2015 SA Q9]
Which one of the following statements best explains the effect of rotenone in causing death in insects and fish?
C Aerobic respiration in the mitochondria would be disrupted. (The electron transport chain occurs on the inner membranes of mitochondria and requires oxygen and produces ATP. Glycolysis occurs in cytoplasm.)

3-93 [VCAA 2015 SA Q10]
Which one of the following statements best explains this observation?
A Rotenone is not absorbed through the cell membranes of people who have eaten poisoned fish. (Rotenone interferes with the electron transport chain involved in aerobic respiration. It is absorbed by fish tissue as the fish die.)

3-94 [VCAA 2015 SA Q12]
Which one of the following is the correct conclusion that can be drawn from this data?
C Cell X could be a heart-muscle cell from a mammal. (Cell W contains chloroplasts so cannot be from an insect. Cell Y lacks chloroplasts so is not from a green leaf. Cell Z, if it was from root tissue would not possess chloroplasts. Cell X, if from muscle tissue would be expected to have many mitochondria.)

3-95 [VCAA 2012 E1 SA Q21]
C sunlight. (Fact. Light energy is converted during photosynthesis into chemical energy stored in glucose. This energy is converted into the energy stored in ATP in cellular respiration.)

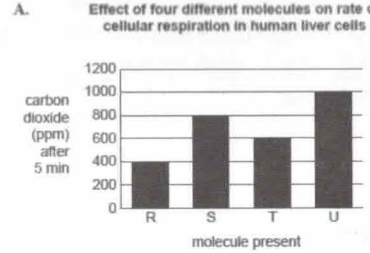
3-96 [VCAA 2012 E1 SA Q22]
The process that produces the largest number of ATP molecules is
D the electron transport chain in cellular respiration. (Fact. Synthesis requires the conversion of ATP to ADP, glycolysis and the light-independent reactions produce only a small amount of ATP.)

3-97 [VCAA 2014 SA Q12]
Referring to the information above and your knowledge of cellular respiration, which one of the following conclusions can be made?
D One fatty acid X molecule produces more ATP in aerobic conditions than one glucose molecule does. (6 ATP molecules and therefore 6 molecules of acetyl CoA are produced for each glucose molecule in aerobic respiration. The stem of the question tells you that 8 molecules of acetyl CoA are produced for each fatty acid.)

3-98 [VCAA 2019 SA Q12]
During which process would the production of lactic acid be observed?
B fermentation in animals. (Fact: Lactic acid is produced during anaerobic respiration in animals, i.e. fermentation. In plants, the by-products are ethanol and carbon dioxide rather than lactic acid.)

3-99 [VCAA 2020 SA Q40]
Which one of the following graphs is the best representation of the results?

A.



(The data is not continuous – it is discrete in that measurements were taken in four different separate situations. Therefore a histogram is most appropriate.)

3-100 [VCAA 2019 SA Q13]
The rate of aerobic cellular respiration in a human cell may increase if the
B oxygen concentration available to the mitochondria increases. (An increase in oxygen concentration, a reactant, for aerobic respiration will increase the rate of aerobic respiration. Decrease in temperature will slow respiration as will increases carbon dioxide concentration or a reduced level of glucose.)

3-101 [VCAA 2018 SA Q11]
Which one of the following statements is correct?
C Group 3's measurements are precise but not accurate. (Group 3's readings were within a tight range – hence they were precise. They were, however, a degree off the actual figure – hence not accurate.)

3-102 [VCAA 2018 SA Q12]
Which one of the following statements about the experiment's results can be concluded from the graphs?
D Group 4's results are more reliable than the other groups'. (Other results may be more valid and more accurate but from the results, group 4's result for a particular concentration is the most consistent (measurements closer together) – therefore the most reliable.)

Chapter 3: Short-answer questions

3-103 [VCAA 2019 SB Q11]

a Measurements of a variable that are close in value are precise therefore the measurements taken at 35°C are the most precise as they vary by 1s whereas 25°C by 2 s, 15°C by 4 s and 5°C by 3 s.

b The data is quantitative as it expressed numerically whereas qualitative data is descriptive.

c Measurements for 15°C and 25°C have errors.
Possible sources of energy include: (any two)
- adding less sodium bicarbonate solution to the test tube
- adding a larger volume of lipase solutions to the test tube
- incorrect measurement of volume of fatty solution
- incorrect measurement of the time
- incorrect measurement of pH

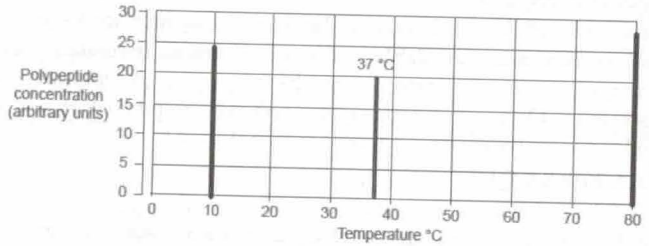
d Type of error: systematic
Source of error (any one)
- incorrect calibration of the pH meter
- consistent incorrect measurement of the volume of lipase solution.

e Any one of the following:

Limitation	Address of limitation
Limited temperature range (measured only up to 35°C)	Use a wider range of temperatures
No control	Include a sample without lipase

3-104 [VCAA 2012 E1 SB Q5]

a



b **10°C**: At low temperatures there are fewer collisions between the polypeptides and digestion enzymes therefore the breakdown reaction is slow and there would be more polypeptides present than at 37°C.

80°C: At high temperatures enzymes are denatured therefore, the reaction rate will be very slow, and the polypeptide concentration will be the highest.

3-105

a To investigate the effect of different pHs on enzyme activity.

b Validity would be improved by including a control group. This group would be exactly the same except it would lack the enzyme. This would show that change in pH alone, does not result in breakdown of substrate.

Also, take observations for a longer time and for the same time interval for each pH. This would allow direct comparisons to be made. (Note: Validity refers to using a control and reliability refers to repetition.)

c

Student	Observation at end of trial
1	clear
2	clear
3	clear
4	clear
5	cloudy
6	cloudy

3-106 [VCAA 2020 SB Q3]

a Chemical reactions in photosynthesis are controlled by enzymes. Enzymes have an optimum temperature where the reaction rate is fastest. At low temperatures, the reaction rate is slow as the substrate and enzymes have low kinetic energy and collisions are low. At high temperatures, the active site is denatured. Therefore, if the greenhouses are maintained at the enzyme's optimal temperature, the rate photosynthesis will be highest.

b Red and blue wavelengths of light are absorbed during the light-dependent stage of photosynthesis. Green light is not. Converting green light to red light increases the amount of light available to plants and therefore increases the rate of photosynthesis.

c Any two of the following features of chloroplasts:
- They are surrounded by a double membrane suggesting that the internal membrane was the outer membrane of the bacteria and the outer membrane, the cell membrane of the cell that engulfed the bacteria by phagocytosis.
- They contain a circular DNA chromosome similar to that found in bacteria.
- They contain small ribosomes similar to those found in bacteria.
- They can reproduce independently within the cell by binary fission like bacteria.
- They are similar to bacteria in size and shape.

3-107 [VCAA 2019 SB Q2]

a i Carbon dioxide and water

ii Region R is the stroma. The grana are the site of the light-dependent stage of photosynthesis where light is absorbed, and water is split to form H^+ and oxygen. The oxygen then diffuses into the stroma and into R, across the chloroplast membrane into the cytoplasm and then out of the cell. When the plant is photosynthesising, oxygen will be produced therefore there will be a higher concentration in region R than when the plant is not photosynthesising.

b NADPH: The hydrogen produced in the light-dependent stage binds with $NADP^+$ to form NADPH. The NADPH moves into the stroma and delivers hydrogen for the light-independent reaction/Calvin cycle.

ATP: is produced as a result of light absorption and the splitting of water in the light-dependent stage of photosynthesis. It then diffuses into the stroma where it breaks down to ADP and P_i. The energy released is used in the light-independent stage/Calvin cycle to join hydrogen to carbon dioxide to make triose/glucose.

3-108 [VCAA 2015 SB Q3]

a **X** Granum or thylakoid sac

b

Name of the stage of photosynthesis that occurs at X	Light-dependent stage
Two input molecules that are required for reactions at X	Any two: water or ADP or NADP or P_i
Two output molecules that result from reactions at X	Any two: Oxygen or ATP or $NADPH/H^+$

3-109 [VCAA 2018 SB Q11]

a Red-algae photosynthesise more than green algae in green light.

b Any three of:
- amount of algae present/number of algal balls in each tube
- initial CO_2 concentration
- initial pH
- amount of phenol red added
- temperature

c Independent variables: type of algae
Dependent variable: CO_2 concentration or colour of solution or pH

d The hypothesis would be disproved if all test tubes were the same colour or if the test tubes containing green algae became pinker than the test tubes containing red algae. (Both required)

e An identical experiment in the dark would show that any change in colour was due to the presence of light and not some other factor.

f Any two of:
- the number of algal cells may be different in each type of algal ball
- the jelly in the balls may have changed the colour
- the phenol red may affect the rate of photosynthesis differently in each type of algae
- the phenol red may naturally change colour.

3-110 [VCAA 2011 E1 SB Q7]

a $C_6H_{12}O_6 + 6O_2 + 36\ ADP + 36\ P_i \rightarrow 6CO_2 + 6H_2O + 36ATP$
Or
glucose + oxygen → carbon dioxide + water + energy

b The cristae of mitochondria are the sites where the electron transport chain reactions of aerobic respiration occur. Most of the ATP (32 molecules per molecule of oxygen) produced during aerobic respiration occurs here. If they cannot occur, not enough ATP (4 molecules per molecule of oxygen) is produced to sustain life.

c Light is absorbed by chlorophyll at X. As a result, water is split. The oxygen is given off and the hydrogen ions combine with NADP to form NADPH. Some ATP (18 molecules) is formed.

d i At M the rate of carbon dioxide taken up for photosynthesis is equal to the rate of carbon dioxide produced in cellular respiration.

ii At 600 units of absorbed light the graph flattens because the chlorophyll is saturated with light and therefore cannot absorb more light.
Or
Carbon dioxide is a limiting factor. Carbon dioxide is required by photosynthesis. If there is not enough carbon dioxide the reaction will not increase in rate.
Or
The concentration of enzymes controlling photosynthesis is a limiting factor.

e When levels of carbon dioxide are low, oxygen will compete to bind with RuBisCo. As a result, less carbon dioxide will react and photosynthesis will be reduced.
Or
When levels of carbon dioxide are low, oxygen will bind with RuBisCo and this will result in higher levels of hydrogen peroxide and ammonia. These are harmful to the cell.
Or
When carbon dioxide levels are high there will be an increased rate of photosynthesis and therefore more glucose produced for the plant.

3-111 [VCAA 2017 SB Q11]

a Aerobic respiration

b Dependent variables: CO_2 concentration and O_2 concentration
Independent variable: temperature in the chamber (not just temperature)

c The temperature in the chamber was measured for 4 minutes to check that the temperature of the chamber was stable/constant therefore any change in the measurements will be due to temperature change and not some other factor.

d Any two of:
- Use more than one cockroach and average the results. If only one cockroach is used and this individual is atypical of all cockroaches then the results could not be used as a basis for generalisation. Using more than one cockroach and averaging the results reduces the effect on the results of atypical results.
- Ensure the humidity within the chamber is constant and the same for each repeat. If the cockroach became dehydrated, this could affect its respiration rate.
- Ensure the experiment is conducted at the same time each day as cockroaches maybe active at different times of the day and this could affect the respiration rate.
- Feed the cockroaches at the same time each day and with the same food. Glucose is a reactant in aerobic respiration and therefore its availability could affect the respiration rate.

e i When the temperature was kept constant at 30°C, the levels of carbon dioxide increased at a steady rate from 0.04% to 0.07%. When the temperature dropped from 30°C to 10°C carbon dioxide levels continued to increase from 0.07% to 0.09% but at a slower rate.
When the temperature was kept constant at 30°C, the levels of oxygen showed a steady decrease from 22% to 18%. When the temperature dropped from 30°C to 10°C, oxygen levels continued to decrease from 18% to 16% but at a slower rate.

ii Conclusion: For cockroaches, the rate of aerobic respiration is dependent on the temperature of the chamber. Low temperatures lower the rate of aerobic respiration. In this experiment, the independent variable was temperature. All other factors were kept constant, therefore any change in carbon dioxide levels or oxygen levels must be due to temperature alone. Carbon dioxide can be used as a dependent variable as it is a product of aerobic respiration and therefore when its levels increase, aerobic respiration is occurring. Oxygen can also be used as a dependent variable as it is a reactant in aerobic respiration therefore when its levels decrease, aerobic respiration is occurring.

3-112 [VCAA 2016 SB Q4]

Experiment 1 – Suspension of mitochondria

Substance added	Change in oxygen concentration (increase/decrease/no change)	Reason
glucose	no change	Oxygen is required when water is formed by the electron transport chain, which occurs on the inner membranes of the mitochondria and requires H^+ formed in the Krebs cycle. Pyruvate not glucose enters the mitochondria therefore H^+ would not be available to the electron transport chain.

pyruvate	decrease	Pyruvate enters the mitochondria and as a result of the Krebs cycle H^+ are formed. The H^+ combine with oxygen at the end of the electron transport chain forming water.

Experiment 2 – Cytosol of cells from which the mitochondria had been removed

Substance added	Change in oxygen concentration (increase/decrease/no change)	Reason
glucose	no change	Glycolysis occurs in the cytosol and is anaerobic. Oxygen is not a reactant or product of glycolysis.
pyruvate	no change	Pyruvate is a product of glycolysis. Oxygen is not a reactant or product of glycolysis which occurs in the cytosol.

Experiment 3 – Suspension of mitochondria and cytosol of cells

Substance added	Change in oxygen concentration (increase/decrease/no change)	Reason
glucose	decrease	In the cytosol, glucose is broken down to pyruvate. The pyruvate enters the mitochondria where through the Krebs cycle H^+ are produced. The H^+ then enter the electron transport chain where finally they combine with oxygen to form water.
pyruvate	decrease	Pyruvate enters the mitochondria where through the Krebs cycle H^+ are produced. The H^+ then enter the electron transport chain where finally they combine with oxygen to form water.

3-113 [VCAA 2012 E1 SB Q8]

a **i** input X: water

ii compound Y: oxygen

b

Process	Name of process	Site of process
M	**light-dependent stage of photosynthesis**	grana of chloroplast
O	glycolysis	**cytosol**
P	stages of respiration	**mitochondria**

c Carbon dioxide is used in photosynthesis. If the rate of carbon dioxide uptake during photosynthesis in *Chlorella* is greater than the rate of carbon dioxide production during cellular respiration then less carbon dioxide will be produced than used.

d Any two of the following:
- suitable light intensity
- suitable light quality
- suitable temperature
- suitable pH
- prevention of disease
- sufficient supply of mineral ions
- sufficient space

3-114 [VCAA 2012 E1 SB Q1]

a Name: plasma/cell membrane (Not just membrane)

Description: the plasma membrane consists of a phospholipid bilayer with the fatty acid chains on the inside and phosphate heads on the outside. Proteins and glycoproteins are studded in the bilayer. Some of the proteins form channels that cross the membrane.

b The structures labelled Y are mitochondria. They are the site of aerobic respiration. If they become less efficient, less ATP will be available for the cell to do work and the cell will have impaired functioning. The person will tire more easily than when they were younger.

3-115 [VCAA 2013 SB Q1]

a Yeast cells have respired both aerobically and anaerobically. Oxygen is a reactant in aerobic respiration therefore if aerobic respiration occurs; the percentage of oxygen will decrease. Ethanol is a product of anaerobic respiration therefore, if anaerobic respiration occurs, the percentage of ethanol will increase.

b Prediction: carbon dioxide concentration would increase.

Explanation: The container that the yeast is in, is airtight. Carbon dioxide is a product of both aerobic and anaerobic respiration therefore its concentration will increase with time. Note: not just a reference to respiration.

c **i** The light-independent stage or the Calvin cycle

ii

Name of input (any two)	Role
ATP	Energy source for the addition of hydrogen to carbon dioxide to form a carbohydrate/glucose
NADPH	NADP transports H^+ ions to the stroma where the Calvin Cycle occurs. The H ions are combined with carbon dioxide to form a carbohydrate/glucose
Hydrogen ions	The H^+ ions are combined with carbon dioxide to form a carbohydrate/glucose

3-116 [VCAA 2016 SB Q2]

a Fermentation provides ATP/energy to the yeast cell enabling it to maintain cell structure and function.

b Ethanol, carbon dioxide and ATP. (Not energy)

c Add the same amount of glucose and same amount of alcohol dehydrogenase to two identical beakers. Place the beakers together so that they are exposed to the same environmental conditions. To the first beaker, add 10 grams of furfural. The presence of furfural is the independent variable. Measure the amount of carbon dioxide/alcohol (the dependent variable) produced every 5 minutes. Repeat the experiment many times. If furfural is an inhibiter of

alcohol dehydrogenase, then more carbon dioxide/alcohol will be produced in the first container.

d Furfural could act as a competitive inhibitor if parts of its structure have the same shape as the substrate that binds to the active site of alcohol dehydrogenase. Furfural could then bind to alcohol dehydrogenase blocking the active site, reducing the amount of substrate that could bind to alcohol dehydrogenase.

Chapter 4: How do organisms respond to pathogens?

4-1 Cells in an organism have their own particular molecules on their surfaces (antigens). These molecules are usually made of proteins, carbohydrates, glycoproteins or glycolipids. Cells with different molecules on their surfaces are recognised as foreign or non-self and are attacked by the immune system.

4-2 A pathogen is a disease-causing organism or infectious particle whereas an antigen is a specific molecule recognised by the immune system. Molecules on the pathogens surface may be antigens. An allergen is a molecule that provokes an over-reaction of the immune system. An antibody is a molecule produced as a result of the presence of an antigen

4-3 A disease is any condition that alters the normal functioning of an organism. Infectious diseases are caused by an organism or agent (e.g. virus) that has 'infected' the diseased individual. Not all diseases are infectious. Scurvy and rickets are examples of nutritional diseases. Cancers may be caused by carcinogens in the environment.

4-4 A pathogen is the organism or agent that causes an infectious disease. The adjective pathogenic describes organisms/agents that cause infectious disease.

4-5 The host is the individual that has been invaded by the pathogen. Most pathogens are internal parasites; that is, they obtain food and shelter from their host.

4-6 Non-cellular pathogens include viruses, viroids, and prions. Cellular pathogens include bacteria, fungi and eukaryotic parasites.

4-7 Physical barriers of plants against disease include thick cuticles, hairs, thorns or spikes, thick cell walls and thick bark. Chemical barriers include secretion of resin and antibiotic-like substances called phytoalexins. Caffeine is an example.

4-8 The external barriers of the body are the first line of defence. The skin is relatively tough and impermeable unless broken. The skin produces its own antiseptic – sebum. An antiseptic in tears protects the eyes. Hairs and mucus protect the entrance to the respiratory system. Stomach acid has a role in killing pathogens that enter in food. The vagina's secretions are acidic which helps reduce chances of bacterial or fungal infection. Urine, itself acidic, helps to flush out any pathogens that enter the urethra. Natural flora of microorganisms out-compete harmful microorganisms.

4-9

Component of the innate immune response	Role in the innate immune response
Macrophages	Recognise, engulf and destroy foreign or damaged tissue
Neutrophils	Fast acting and are involved in inflammation. They contain granules which kill engulfed pathogens
Dendritic cells	Find foreign material in body tissue, engulf and then display foreign antigens. They provide a link to the adaptive immune response
Eosinophils	Leucocytes that release cytokines that kill parasites
Natural killer cell	Leucocytes that destroy abnormal or infected cells by triggering apoptosis.
Mast cell	Leucocytes that release histamines increasing inflammation.
Complement proteins	About 20 different proteins that: -stick to invading pathogens, increasing identification by phagocytes. -attract phagocytes to the site of infection and stimulate their activity. - destroy pathogen membranes
Interferon	A type of cytokine produced by infected cells that inhibits the synthesis of new viral proteins within the cell. They also attract natural killer cells to destroy infected cells.

4-10 The functions of inflammation include:
- destruction of the cause and products of an infection
- confining the infection to a small area
- increased rate at which damaged cells are repaired or replaced.

4-11 The stages of inflammation:
- damaged cells and mast cells in blood vessels, gut and lungs release histamines
- histamines increase the diameter and permeability of blood vessels
- this results in increased blood flow to the infected area, heat and swelling
- reduced movement
- plasma fluid, some plasma proteins and phagocytes leave the blood and enter the infected tissue
- phagocytes are attracted by histamines and destroy the pathogens
- macrophages secrete interleukins, which then leads to fever.

4-12 The second line of defence is non-specific in that any pathogen or foreign material can be removed and continues till the pathogen is removed. The scavenger cells involved will attempt to attack any potential threat.

4-13 - Fever increases activity of leucocytes
- Fever can slow the growth of bacteria or the spread of viruses