Insight Publications

INSIGHT

Trial Exam Paper

2006
CHEMISTRY
Written examination 2

Solutions book

This book presents:

- worked solutions, giving you a series of points to show you how to work through the questions
- tips and mark allocations.

SECTION A – Multiple-choice questions

Question 1

Which response does **not** represent one of the energy conversions in a coal-fired power station?

A. chemical → thermal

B. thermal → electrical

C. thermal → mechanical

D. mechanical → electrical

Answer is B

Worked solution

- The stages and energy changes in a coal-fired power station are
  burner: chemical → thermal (So answer **A** is true.)
  boiler: thermal (from burning coal) → thermal (steam)
  (So answer **B** is not true and is the correct response to the question.)
  turbine: thermal → mechanical (So answer **C** is true.)
  generator: mechanical → electrical (So answer **D** is true.)

Question 2

The amount of energy required to increase the temperature of a 500 g block of iron by 50°C is 11.825 kJ. The specific heat capacity of iron, in J g^{-1} $°C^{-1}$, is

A. 4.73×10^{-4}

B. 0.473

C. 47.3

D. 473

Answer is B

Worked solution

- Remember the formula
  Energy (J) = specific heat capacity (J g^{-1} $°C^{-1}$) × mass (g) × temperature rise (°C)
- So, for this question, specific heat capacity (J g^{-1} $°C^{-1}$) $= \dfrac{\text{energy}}{\text{mass} \times \Delta T}$

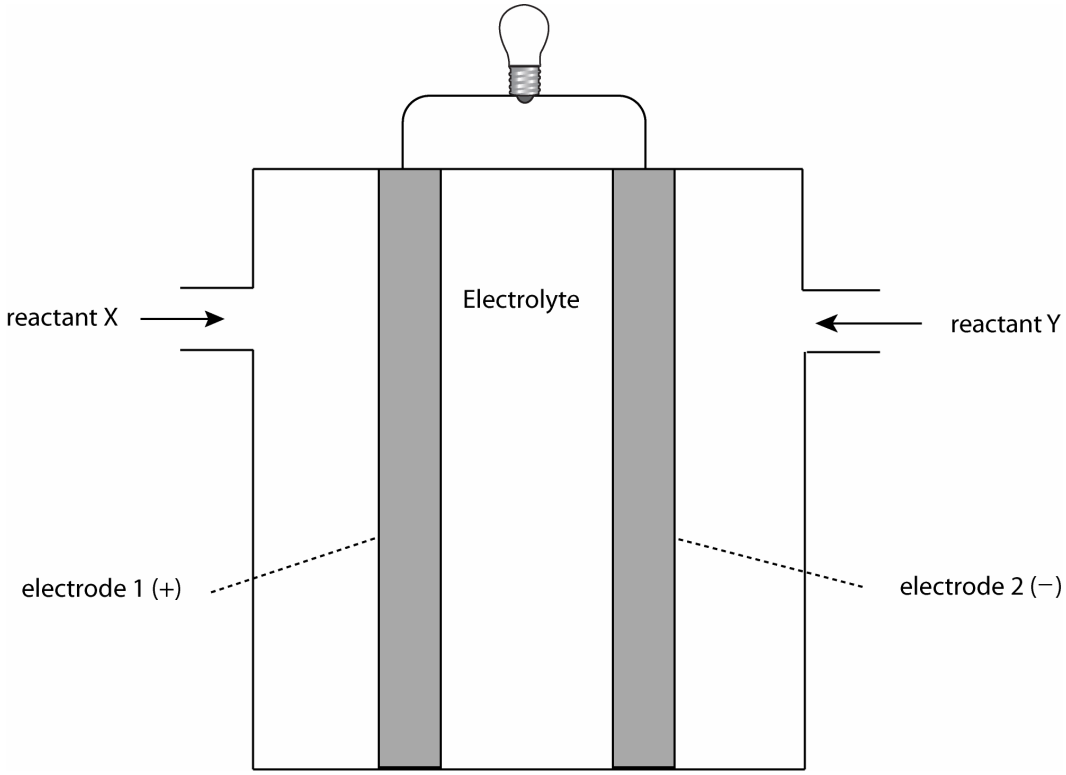
$$= \frac{11\,825}{500 \times 50}$$

$$= 0.473$$

Questions 3 and 4 refer to the following information.

A diagram of a fuel cell designed to use ethanol as a fuel is shown below. The electrolyte is HCl. The cell reaction is

$$C_2H_5OH(aq) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$$



Question 3

Choose the alternative that correctly labels electrodes 1 and 2 and identifies the reactants.

	Electrode 1	**Electrode 2**	**Reactant X**	**Reactant Y**
A.	anode	cathode	$O_2(g)$	$C_2H_5OH(aq)$
B.	anode	cathode	$C_2H_5OH(aq)$	$O_2(g)$
C.	**cathode**	**anode**	**O2(g)**	**C2H5OH(aq)**
D.	cathode	anode	$C_2H_5OH(aq)$	$O_2(g)$

Answer is C

Worked solution

- This is a fuel cell in which spontaneous reactions occur. The cathode will be the positive electrode. Electrode 1 has a positive charge so must be the cathode. Electrode 2 is the anode. Answers **A** and **B** can therefore be eliminated.
- Oxygen gas is the oxidant and is being reduced in this reaction, as its oxidation number drops from 0 to –2. Reduction always occurs at the cathode. Electrode 1 is the cathode so $O_2(g)$ is reactant X.
- Ethanol, which is being oxidised, is reactant Y.

Question 4

In delivering an electric current, a particular cell uses 0.750 g of ethanol in 30.0 minutes. The half equation for the reaction of ethanol is

$$C_2H_5OH(aq) + 3H_2O(l) \rightarrow 2CO_2(g) + 12H^+(aq) + 12e^-$$

The electric current flowing, in amps, is

A. 0.175

B. 0.874

C. 10.5

D. 629

Answer is C

Worked solution

- This question requires the use of formulas that evolved from Faraday's laws. Faraday's first law of electrolysis states that 'the mass of metal deposited at the cathode is directly proportional to the quantity of electricity passed through the cell'. Faraday's second law is 'the number of moles of different substances deposited, evolved or dissolved at electrodes by the passage of the same amount of electric current are inversely proportional to the charges on their ions.'
- Remember: Time needs to be in seconds.
- Step 1: Calculate the number of moles of ethanol.

$$n(\text{ethanol}) = \frac{m}{M}$$
$$= \frac{0.750}{46.0}$$
$$= 0.0163 \text{ mol}$$

- Step 2: Calculate the number of mole of electrons using the mole ratio in the half equation.

$n(e^-) : n(\text{ethanol})$ is 12 : 1

So $n(e^-) = 12 \times n(\text{ethanol})$

$= 12 \times 0.0163$

$= 0.196$ mol

- Step 3: Calculate the charge.

$Q = n(e^-) \times F$

$= 0.196 \times 96\,500$

$= 1.89 \times 10^4$ C

- Step 4: Calculate the current.

$$I = \frac{Q}{t}$$
$$= \frac{1.89 \times 10^4}{30.0 \times 60.0}$$
$$= 10.5 \text{ A}$$

Question 5

The electrolyte used in the electrolytic production of sodium and chlorine in the Downs cell is

A. 1.0 M aqueous sodium chloride.

B. an aqueous mixture of 1.0 M sodium chloride and 1.0 M calcium chloride.

C. molten sodium chloride.

D. a molten mixture of sodium chloride and calcium chloride.

Answer is D

Worked solution

- Molten NaCl must be used rather than aqueous NaCl because water is a stronger oxidant than Na^+ ions and so would be preferentially reduced.
- A mixture of NaCl and $CaCl_2$ is used because it does not require as high a melting temperature as pure NaCl.

Question 6

Most plants can obtain nitrogen for the manufacture of proteins from

A. the absorption of atmospheric nitrogen through their leaves.

B. the absorption of ammonium ions from the soil through their roots.

C. the absorption of amino acids from the soil through their roots.

D. reactions in their leaves that convert atmospheric nitrogen to amino acids.

Answer is B

Worked solution

- Bacteria found in nodules on the roots of leguminous plants fix nitrogen; that is, they convert gaseous nitrogen, N_2, to soluble ammonium ions, NH_4^+. Other bacteria in the soil convert ammonium ions to nitrate ions, NO_3^-, which are also soluble. Plants can absorb NH_4^+ and NO_3^- ions through their roots and use them to make proteins.
- Atmospheric nitrogen must be fixed before plants can use it for the manufacture of proteins, so answer **A** is incorrect.
- Amino acids are the building blocks of proteins that plants manufacture. They are not absorbed through roots, so answer **C** is incorrect.
- Plants are unable to fix nitrogen themselves, so answer **D** is incorrect.

Questions 7 and 8 refer to the following information.

Consider the following nuclear reaction:

$$^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{93}_{36}\mathrm{Kr} + X + 3\,{}^{1}_{0}\mathrm{n}$$

Question 7

In the above equation, X represents

A. $^{142}_{56}\mathrm{Ba}$

B. $^{141}_{56}\mathrm{Ba}$

C. $^{140}_{56}\mathrm{Ba}$

D. $^{139}_{56}\mathrm{Ba}$

Answer is C

Worked solution

- As nuclear reactions are about the rearrangement of atomic nuclei and protons and neutrons cannot be created or destroyed, the mass and atomic numbers must be balanced in the reactants and products. Remember that atomic number is on the bottom and indicates the number of protons. Mass number is on the top and indicates the number of protons plus neutrons.
- Total of mass numbers on the reactant side is 236.
- Mass number of $X = 236 - 93 - 3 \times 1$ (There are three neutrons.)
  $= 140$
- Total of atomic numbers on the reactant side is 92.
- Atomic number of $X = 92 - 36$
  $= 56$
- The symbol of the element with atomic number 56 (i.e. Ba) is obtained from the periodic table.

Question 8

Which of the following best describes this reaction?

A. A nuclear fission reaction that is exothermic.

B. A nuclear fission reaction that is endothermic.

C. A nuclear fusion reaction that is exothermic.

D. A nuclear fusion reaction that is endothermic.

Answer is A

Worked solution

- This is a nuclear fission reaction because a large nucleus is breaking into several smaller nuclei.
- This is an exothermic reaction because the products are more stable than the reactant, as they are closer in size to the Fe nucleus. Remember that the Fe nucleus is the most stable nucleus.

Question 9

The combustion of butane can be represented by the equation

$$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(l) \qquad \Delta H = -5\ 718 \text{ kJ mol}^{-1}$$

When 30.0 kg of butane undergoes complete combustion, the energy produced, in kJ, is

A. 1.48×10^3

B. 1.48×10^6

C. 2.96×10^3

D. 2.96×10^6

Answer is B

Worked solution

- Remember that mass must be in grams.
- Step 1: Calculate the amount (mol) of butane.

$$n(\text{butane}) = \frac{m}{M}$$
$$= \frac{30.0 \times 10^3}{58.0}$$
$$= 517 \text{ mol}$$

- Step 2: Calculate the energy released by 517 mol of butane.
  According to the equation, 2 mol C_4H_{10} releases 5 718 kJ.
  Therefore, 1 mol C_4H_{10} releases $\frac{5\ 718}{2}$ kJ.
  Energy released = $n(C_4H_{10}) \times$ energy released per mol C_4H_{10}
  $$= 517 \times \frac{5\ 718}{2}$$
  $$= 1.48 \times 10^6 \text{ kJ}$$

Question 10

The lead-acid car battery discharges according to the chemical reaction represented by the equation below.

$$Pb(s) + PbO_2(s) + 2SO_4^{2-}(aq) + 4H^+(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$$

The reaction that occurs at the anode when the battery is being recharged is

A. $PbSO_4(s) + 2e^- \rightarrow Pb(s) + SO_4^{2-}(aq)$

B. $PbO_2(s) + SO_4^{2-}(aq) + 4H^+(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$

C. $Pb(s) + SO_4^{2-}(aq) \rightarrow PbSO_4(s) + 2e^-$

D. $PbSO_4(s) + 2H_2O(l) \rightarrow PbO_2(s) + SO_4^{2-}(aq) + 4H^+(aq) + 2e^-$

Answer is D

Worked solution

- Remember that the products of the discharging reaction are the reactants for the recharging reaction. Hence, $PbSO_4$ will be a reactant in the oxidation half equation during recharging reactions.
- The anode reaction is always oxidation (i.e. the loss of electrons). Answers **A** and **B** are reduction reactions and so can be eliminated.
- The recharge reaction will be the reverse of the given discharge reaction. Hence, the correct answer is **D**.

Question 11

The number of neutrons in an atom of $^{230}_{90}Th$ is

A. 90

B. 140

C. 230

D. 320

Answer is B

Worked solution

- Number of neutrons = mass number – atomic number = 230 – 90 = 140

Question 12

An ion with a charge of positive two, and the same electron configuration as the fluoride ion, is the

A. nitride ion.

B. oxide ion.

C. sodium ion.

D. magnesium ion.

Answer is D

Worked solution

- The atomic number of fluorine, which is 9, can be obtained from the periodic table.
- A neutral fluorine atom contains 9 electrons and has an electronic configuration of $1s^2 2s^2 2p^5$.
- Fluorine is a non-metal and has an almost complete second shell. It forms a negatively charged ion by gaining a single electron. Therefore, the fluoride ion contains 10 electrons and has an electronic configuration of $1s^2 2s^2 2p^6$.
- An ion that has a charge of +2 has two fewer electrons than its neutral atom. If the ion contains 10 electrons, like the fluoride ion, the atom must contain 12 electrons.
- A neutral atom with 12 electrons will have an atomic number of 12. From the periodic table, the element with an atomic number of 12 is magnesium. It has the electronic configuration of $1s^2 2s^2 2p^6 3s^2$.

Question 13

The element chlorine occurs naturally as two isotopes, ^{35}Cl and ^{37}Cl. The ^{35}Cl atom has a relative isotopic mass of 34.696 and ^{37}Cl has a relative isotopic mass 36.966. The relative atomic mass of chlorine is 35.5. The percentage abundance of the lighter isotope is

A. 33.2%

B. 48.6%

C. 64.6%

D. 80.0%

Answer is C

Worked solution

- Let the abundance of the lighter isotope be x. Therefore, the abundance of the heavier isotope will be $100 - x$.

$$A_r = \frac{\sum(\text{isotopic mass} \times \text{abundance})}{100}$$

$$35.5 = \frac{(34.696 \times x) + (36.966 \times (100 - x))}{100}$$

$$3550 = 34.696x + 3696.6 - 36.966x$$

$$3550 - 3696.6 = 34.696x - 36.966x$$

$$-146.6 = -2.27x$$

$$x = 64.6\%$$

Question 14

The tripeptide formed from the reaction of three alanine molecules, $NH_2CH(CH_3)COOH$, will have a relative molecular mass of

A. 213

B. 231

C. 249

D. 267

Answer is B

Worked solution

- The relative molecular mass of one alanine molecule is 89.
- The total of the three molecules is 267.
- Remember that linking three molecules together requires two condensation reactions between amino and carboxyl groups, and so will eliminate two water molecules. Water has a relative molecular mass of 18.
- $3NH_2CH(CH_3)COOH \rightarrow NH_2CH(CH_3)CONHCH(CH_3)CONHCH(CH_3)COOH + 2H_2O$
- Therefore, the relative molecular mass of the tripeptide = $267 - (2 \times 18)$
  $= 231$

Question 15

The human body cannot obtain any energy from the polysaccharide cellulose. This is because

A. cellulose is not present in any of the foods we eat.

B. the molecules produced from the digestion of cellulose cannot be absorbed by the gut.

C. the molecules produced from the digestion of cellulose are unable to be oxidised in human body cells.

D. the human body lacks the enzyme required to digest cellulose.

Answer is D

Worked solution

- Enzymes are extremely specific, with one enzyme catalysing one reaction. The inability of the human body to digest cellulose is a good example of this. The human body does not produce an enzyme that is able to catalyse the breakdown of cellulose.
- Cellulose is a polysaccharide used for physical structure in plants.

Question 16

This reaction is an important reaction in the carbon cycle.

$$6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$$

Which one of the following alternatives correctly names and describes the energy change that occurs in this reaction?

	Name	**Energy change**
A.	**photosynthesis**	**endothermic**
B.	photosynthesis	exothermic
C.	respiration	endothermic
D.	respiration	exothermic

Answer is A

Worked solution

- The reaction between carbon dioxide and water to produce glucose and oxygen is photosynthesis and occurs in all green plants. It requires energy from sunlight to occur and so is endothermic.
- Respiration is the reverse of this reaction and is the combustion of glucose, which occurs in all living cells. It releases energy.

Question 17

The membrane cell is used to produce chlorine gas electrolytically. Which one of the following alternatives correctly describes the electrolyte and reaction at the anode?

	Electrolyte	**Anode reaction**
A.	molten NaCl	$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$
B.	molten NaCl	$2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$
C.	aqueous NaCl	$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$
D.	**aqueous NaCl**	$\mathbf{2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-}$

Answer is D

Worked solution

- The aqueous NaCl used is highly concentrated to ensure that chloride ions, rather than water molecules, are oxidised at the anode.
- $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$ is the cathode reaction. Water molecules are stronger oxidants than sodium ions, so water reacts preferentially. The Na^+ ions combine with the OH^- ions so that NaOH is also a product.

Question 18

The group 2 elements in the periodic table have an outer shell electron configuration of

A. $\mathbf{s^2}$
B. p^2
C. d^2
D. s^2 or p^2

Answer is A

Worked solution

- The group 1 and 2 elements are part of the s block on the periodic table, indicating that the outer shell of each is the s subshell.
- The group number of any element indicates the number of electrons in its outer shell.

Question 19

The compound that is used as a short-term energy reserve in the human body is

A. galactose

B. glycine

C. glycerol

D. glycogen

Answer is D

Worked solution

- Glycogen is a condensation polymer of glucose that is stored in the liver and in muscle tissue. As energy is required, the glycogen is hydrolysed to yield glucose for respiration.
- Galactose is a monosaccharide that exists only as part of the disaccharide lactose.
- Glycine is an amino acid.
- Glycerol combines with fatty acids to form triglycerides.

Question 20

Which one of the following metals would you predict to react spontaneously with lead ions but not zinc ions?

A. Cu

B. Al

C. Sn

D. Mg

Answer is C

Worked solution

- Refer to the electrochemical series when predicting redox reactions. A relevant section is shown below.
  $Cu^{2+}(aq) + 2e^- \rightarrow Cu$
  $Pb^{2+}(aq) + 2e^- \rightarrow Pb$
  $Sn^{2+}(aq) + 2e^- \rightarrow Sn$
  $Zn^{2+}(aq) + 2e^- \rightarrow Zn$
  $Al^{3+}(aq) + 3e^- \rightarrow Al$
  $Mg^{2+}(aq) + 3e^- \rightarrow Mg$
- The metal must be below lead (Pb) but above zinc (Zn) in the electrochemical series. Tin (Sn) is the only metal that meets these criteria.
- Copper (Cu) is higher in the series than both lead and zinc, and so will react with the ions of neither.
- Aluminium (Al) and magnesium (Mg) are lower in the series than both lead and zinc, and so will react with the ions of both.

END OF SECTION A

SECTION B – Short-answer questions

General note:

- *Asterisks indicate where marks are earned.*

Question 1

Give the chemical symbol for

1a. the element that forms a +2 ion with the electron configuration $1s^2 2s^2 2p^6$.

Answer

Mg*

1 mark

Tip

- *A +2 ion has lost two electrons. The ion above has 10 electrons, so the total number of electrons in a neutral atom would be 12. Since the element has an atomic number of 12, it is magnesium. The magnesium atom has the electron configuration $1s^2 2s^2 2p^6 3s^2$.*

1b. the amino functional group.

Answer

NH_2*

1 mark

Tip

- *The amino functional group is an important functional group found in all amino acids.*

1c. a nitrogen-containing compound that is the end waste product of the digestion of proteins in the human body.

Answer

$CO(NH_2)_2$*

1 mark

Tip

- *Urea is excreted in urine by the human body.*

Total 3 marks

Question 2

Oleic acid, $C_{17}H_{33}COOH$, is a common fatty acid.

2a. Is oleic acid a saturated or unsaturated fatty acid?

Answer

Unsaturated*

1 mark

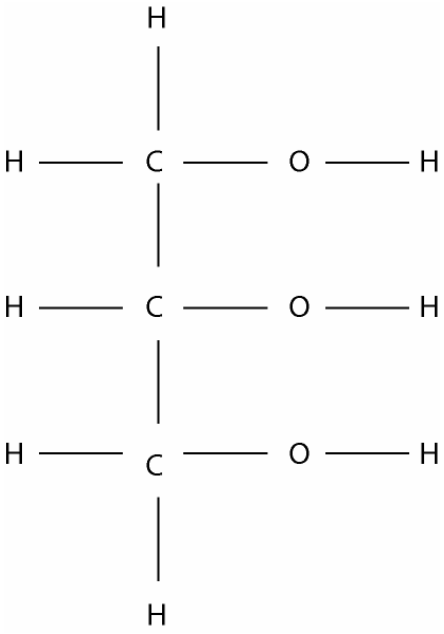
Tips

- *An unsaturated fatty acid contains at least one double carbon = carbon bond.*
- *The hydrocarbon tail of a saturated fatty acid will have the formula C_nH_{2n+1}. Unsaturated fatty acids will not fit this.*
- *Also, the molecular formula of a saturated fatty acid is $C_nH_{2n}O_2$.*
- *The molecular formula of oleic acid is $C_{18}H_{34}O_2$. It has two fewer hydrogens than are required to be saturated, so it is a monounsaturated fatty acid.*

2b. A triglyceride is produced by a reaction between three fatty acid molecules, such as oleic acid, and one other molecule. Name the other molecule and draw its structural formula.

Answer

Glycerol*



2 marks

2c. Oleic acid forms almost one-third of the total fatty acid content in cow's milk. During the processing of cow's milk into other foods, additives are often added to prevent the foods from spoiling in air.

2c. i. What feature of oleic acid makes it particularly susceptible to spoiling in air?

Answer

The double carbon = carbon bond.*

2c. ii. What class of additives is added to prevent this type of spoiling?

Answer

Anti-oxidants*

1 + 1 = 2 marks

Tip

- *Remember that anti-oxidants work by reducing the atmospheric oxygen before it can oxidise the fatty acid. Vitamin C is a common example.*

Total 5 marks

Question 3

The energy content of a new brand of biscuits was determined by a series of experiments using a bomb calorimeter. The calorimeter is first calibrated by passing an electric current though the calorimeter for a period of time and measuring the resultant temperature rise. The following data was collected.

Current	1.35 A
Potential difference	6.50 V
Time	5.00 min
Temperature rise	1.05°C

3a. Use the data above to calculate the calibration factor, in kJ $°C^{-1}$ for this calorimeter.

Answer

Energy released into water = VIt

$= 6.50 \times 1.35 \times 5.00 \times 60.0$

$= 2632.5$ J

$= 2.63*$ kJ

$$\text{Calibration factor} = \frac{\text{Energy}}{\Delta T}$$

$$= \frac{2.63}{1.05}$$

$= 2.51*$ kJ $°C^{-1}$

2 marks

Tip

- *Remember that the* E = VIt *calculation gives energy in joules, not kilojoules. Also, time needs to be in seconds.*

3b. A mass of 2.34 g of the dried biscuit was then burnt in the calorimeter and a temperature change of 0.570°C was recorded. Calculate the energy content of the biscuits in kJ g^{-1}.

Answer

Energy released by 2.34 g biscuit = calibration factor × ΔT

$= 2.51 \times 0.570$

$= 1.43^*$ kJ

$$\text{Energy content in kJ g}^{-1} = \frac{\text{energy released}}{\text{mass of biscuit}}$$

$$= \frac{1.43}{2.34}$$

$= 0.611^*$ kJ g^{-1}

2 marks

3c. Why is the energy content of the biscuit given in kJ g^{-1} rather than in kJ mol^{-1}?

Answer

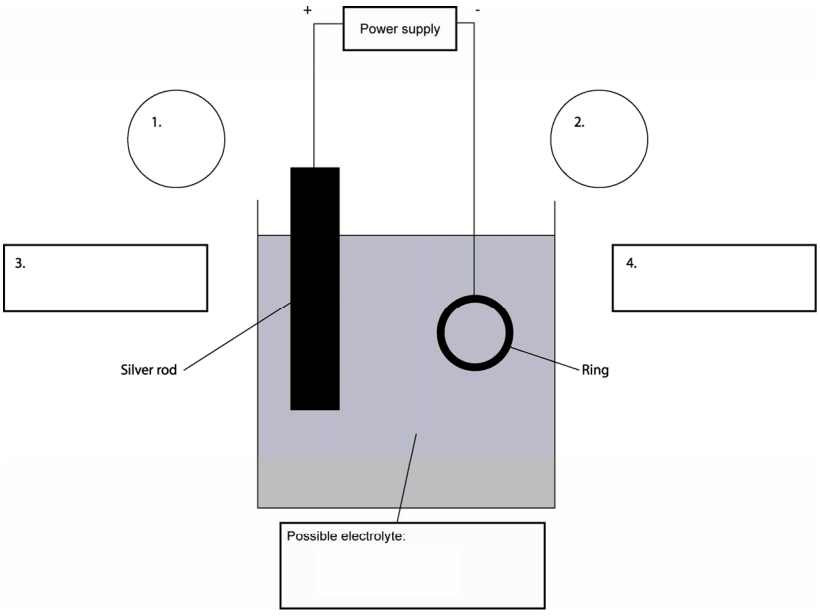
The biscuit is not made up of a pure substance.* It is made up of a mixture of many different chemicals and cannot be assigned a representative molar mass.

1 mark

Total 5 marks

Question 4

Electrolysis is used to coat an iron ring with silver metal. A sketch of the experimental set-up is given below.



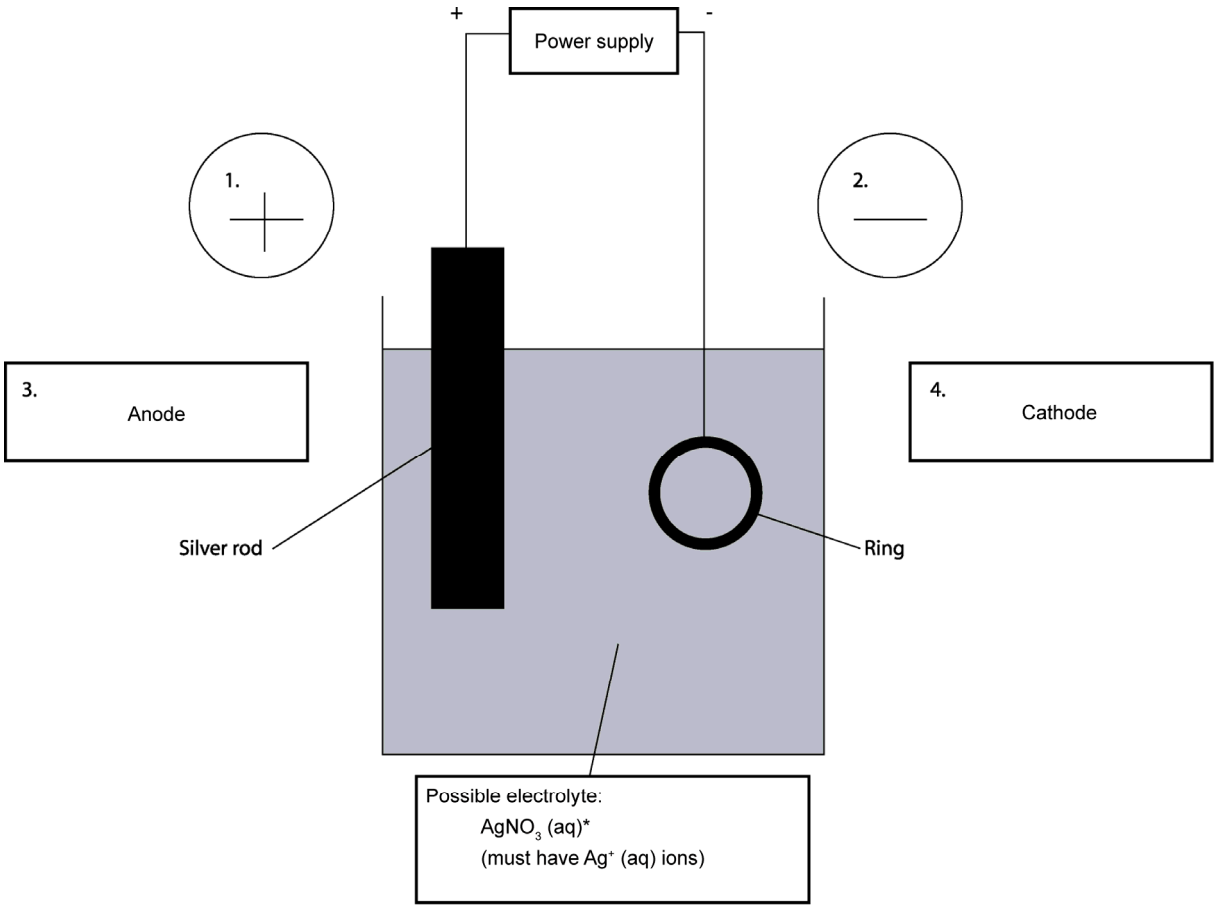
4a. On the diagram above

i. label the polarity of the electrodes at points 1 and 2.

ii. label the anode and cathode at points 3 and 4.

iii. write the formula of a possible electrolyte in the space provided.

Answer



1 + 1 + 1 = 3 marks

Marks

- *1 mark is awarded for correctly labelling both the anode and cathode.*
- *1 mark is awarded for correctly labelling the polarity of both of the electrodes.*
- *1 mark is awarded for naming an appropriate electrolyte containing Ag^+(aq) ions.*

4b. Write an equation for the half reaction that occurs on the surface of the ring.

Answer

$Ag^+(aq) + e^- \rightarrow Ag(s)$*

1 mark

Tip

- *The half reaction at the surface of an item being electroplated with another metal will always be a reduction reaction, with electrons being gained.*

4c. A current of 3.00 A is passed through the cell for 15.0 minutes. Calculate the mass of silver that would be deposited on the ring in that time.

Answer

Step 1: determine the quantity of electric charge passing through the cell.

$Q = It$
$= 3.00 \times 15.0 \times 60.0$
$= 2.70 \times 10^3$* C

Step 2: determine the number of moles of electrons passing through the cell.

$$n(e^-) = \frac{Q}{F}$$
$$= \frac{2.70 \times 10^3}{96\,500}$$
$= 0.0280$* mol

Step 3: determine the number of moles of Ag deposited on the ring.

$n(Ag) : n(e^-)$ is 1 : 1

So, $n(Ag) = \frac{1}{1} \times n(e^-)$
$= 0.0280$ mol

Step 4: determine the mass of Ag deposited on the ring.

$m(Ag) = nM$
$= 0.0280 \times 107.9$
$= 3.02$* g

3 marks

Total 7 marks

Question 5

Give a concise explanation for each of the following.

5a. When aluminium oxide is electrolysed industrially, the carbon anodes need to be replaced regularly.

Answer

Oxidation of oxide ions takes place at the anode*
O^{2-} (in cryolite) $\rightarrow O_2(g) + 4e^-$

The resultant oxygen gas reacts with the carbon electrode* according to the equation $C(s) + O_2(g) \rightarrow CO_2(g)$. Hence, the carbon anodes need to be replaced regularly.

2 marks

5b. Secondary cells can be recharged whereas primary cells can be used only once.

Answer

In secondary cells, the products of the discharge reaction remain in contact with the electrodes,* so an electrical current can be applied to convert them back to the original reactants. In a primary cell, the products of the discharge reaction migrate away from the electrodes.*

2 marks

5c. An enzyme that is boiled at 100°C for a few minutes becomes inactive, yet its primary structure remains intact.

Answer

Boiling an enzyme only alters the secondary and tertiary structures.* It is the tertiary structure, not the primary structure that determines the active site and allows the enzyme to operate.*

2 marks

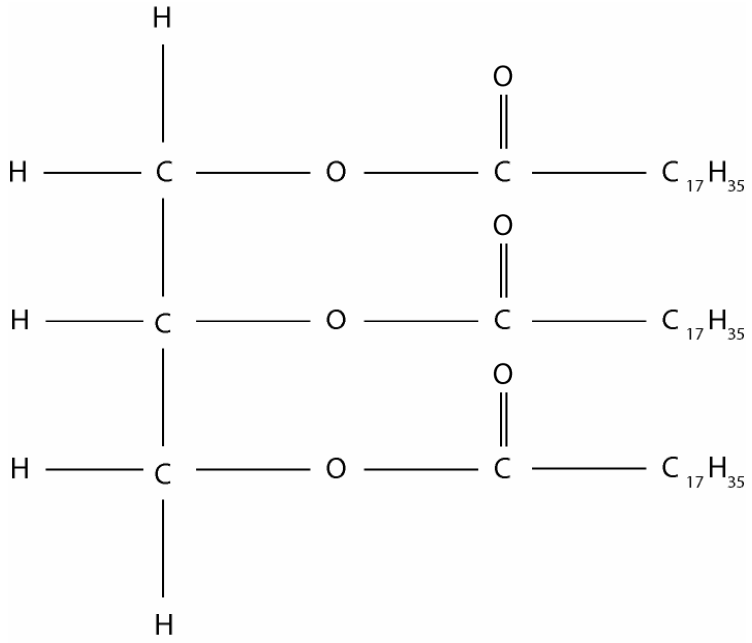
Tips

- *Remember that the primary structure is the order of amino acids that are linked by covalent bonds. Boiling the enzyme does not break these bonds.*
- *Secondary and tertiary structures are held together by weaker bonds.*

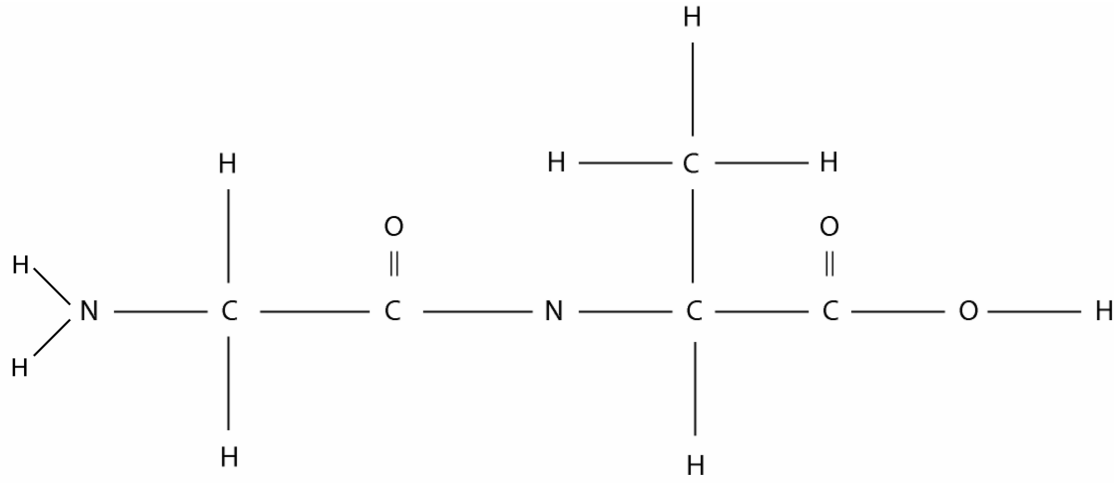
Total 6 marks

Question 6

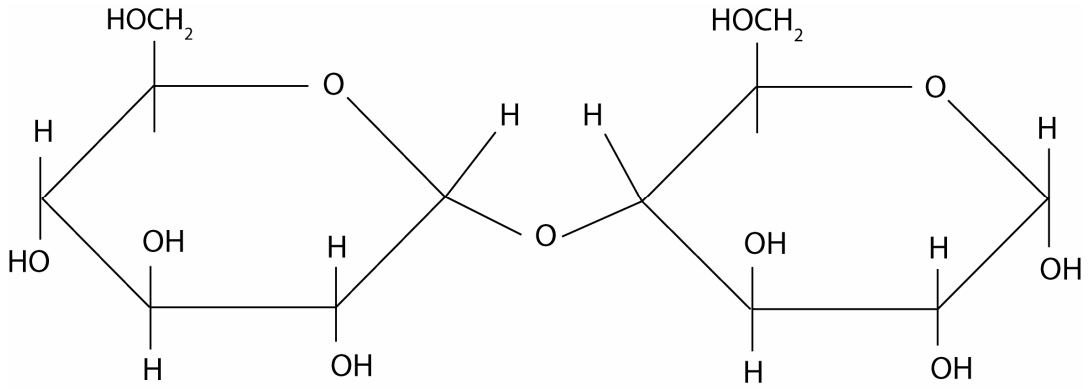
6a. The compounds shown below are all important molecules found in the foods we eat.



Molecule A



Molecule B



Molecule C

6a. i. Which of the molecules shown on page 20, A, B or C, can be digested by the body to produce two amino acids?

Answer

molecule B*

Tip

- *Molecule B is a dipeptide, as indicated by the peptide/CONH covalent bond and by the presence of carboxyl and amide functional groups.*

6a. ii. Name the type of reaction involved in the digestion of this molecule.

Answer

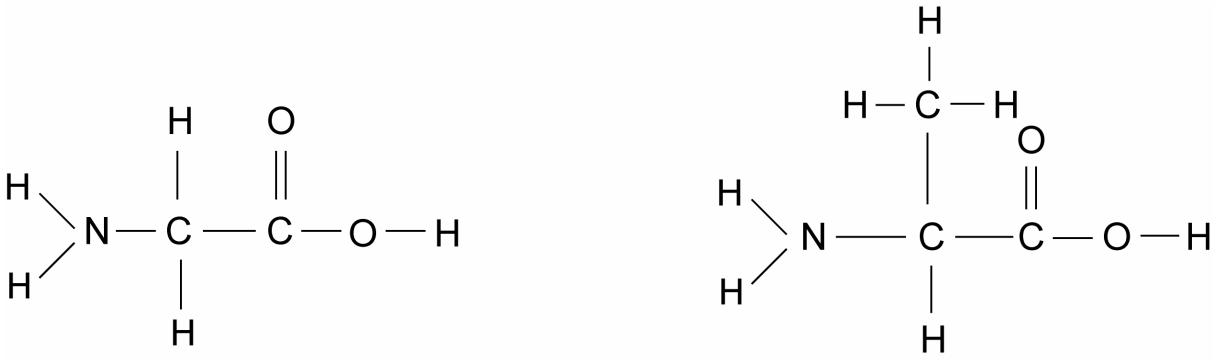
hydrolysis*

Tip

- *Remember that the functional groups in the different nutrients (i.e. peptide in proteins, ether in carbohydrates and ester in fats and oils) are broken down by hydrolysis reactions, that is, reactions in which water is a reactant.*

6a. iii. Draw the structural formulas for the two amino acids formed.

Answer



1 + 1 + 2 = 4 marks

6b. Which of the molecules A, B or C, shown on page 20, can be digested by the body to produce two monosaccharides?

Answer

molecule C*

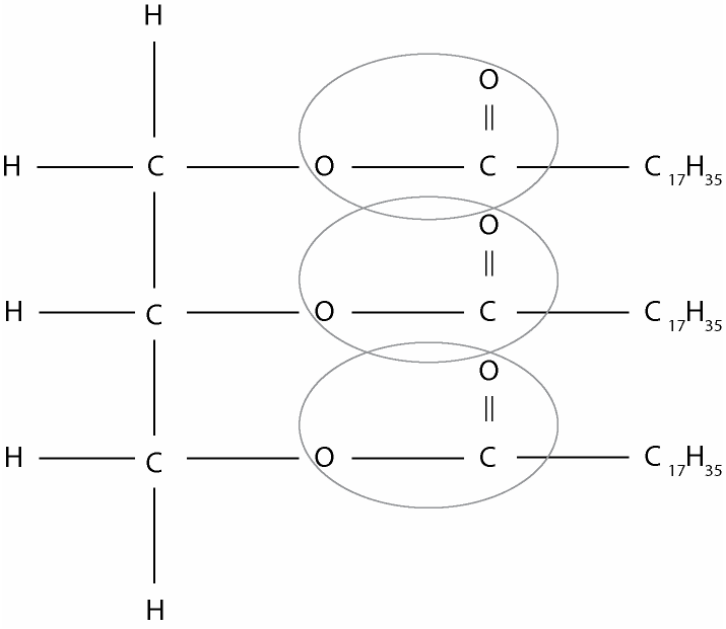
1 mark

Tip

- *Molecule C is sucrose, which is a disaccharide.*

6c. Circle all of the ester linkages present in the molecules A, B and C, shown below.

Answer



1 mark

6d. The digestion of food is catalysed by a large number of different enzymes. Explain how enzymes are able to catalyse the breakdown of food molecules and why so many different enzymes are needed.

Answer

Enzymes have an active site.* The substrate enters this site and bonds are formed between it and the enzyme.* The reactant is converted to products that are released from the active site. Many enzymes are needed because the shape of the active site is specific only to a particular substrate.*

3 marks

Tip

- *Remember that the active site of enzymes depends on their tertiary structure and can be disrupted by changes in temperature and pH. The substrate of an enzyme is made up of molecules that are able to react with the enzyme.*

Total 9 marks

Question 7

The modern periodic table is an extremely useful reference tool for chemists.

7a. Give two ways in which the modern periodic table differs from the one developed by Mendeleev.

Answer

Mendeleev's table places elements in order of increasing mass, not by atomic number.* Mendeleev's table has gaps in it* for elements that were predicted to be discovered. The modern periodic table has no gaps.

2 marks

7b. The elements Li, Be, B, C, N, O and F are all members of period 2 of the periodic table. Consider the following properties of these elements.

First ionisation energy

7b. i. Which of the elements listed above has the highest first ionisation energy?

Answer

F*

Tip

- *Remember that first ionisation energy is the energy required to remove the outermost electron from an atom. It is a measure of how strongly that electron is held to the nucleus.*

7b. ii. Explain the trend in the first ionisation energies of the listed atoms.

Answer

From left to right across the periodic table core charge increases.* As core charge increases, the electrons are held more tightly to the nucleus* and more energy is required to remove the outermost electron.

Atomic radius

7b. iii. Which of the elements listed above has the largest atomic radius?

Answer

Li*

1 + 2 + 1 = 4 marks

Tip

- *Although fluorine (F) has more electrons than lithium (Li), they are still in the same shell. Fluorine has a higher core charge, so all of its electron shells are pulled more tightly towards the nucleus. Lithium, which has the lowest core charge, is the largest atom.*

7c. The elements Be, Mg, Ca, Sr, Ba and Ra are all members of group 2 of the periodic table. Consider the following properties of these elements

First ionisation energy

7c. i. Which of the elements listed above has the highest first ionisation energy?

Answer

Be*

7c. ii. Explain the trend in the first ionisation energies in the atoms of the listed elements.

Answer

Going down a group, the atom size is increasing as the number of occupied shells increases. This means that the outermost electrons are further from the nucleus.* Of the elements listed, beryllium (Be) has the smallest atom, so its outermost electron is held most tightly and requires the most energy to remove.*

Oxidising strength

7c. iii. Which of the listed elements is the strongest oxidant?

Answer

Be*

1 + 2 + 1 = 4 marks

Tip

- *Oxidising strength reflects an atom's ability to attract electrons to the outer shells. This decreases down the group as the atoms get larger and the outer shell is further from the nucleus.*

Total 10 marks

Question 8

The transition metals occupy the d block in the periodic table.

8a. Why is the d block 10 elements wide?

Answer

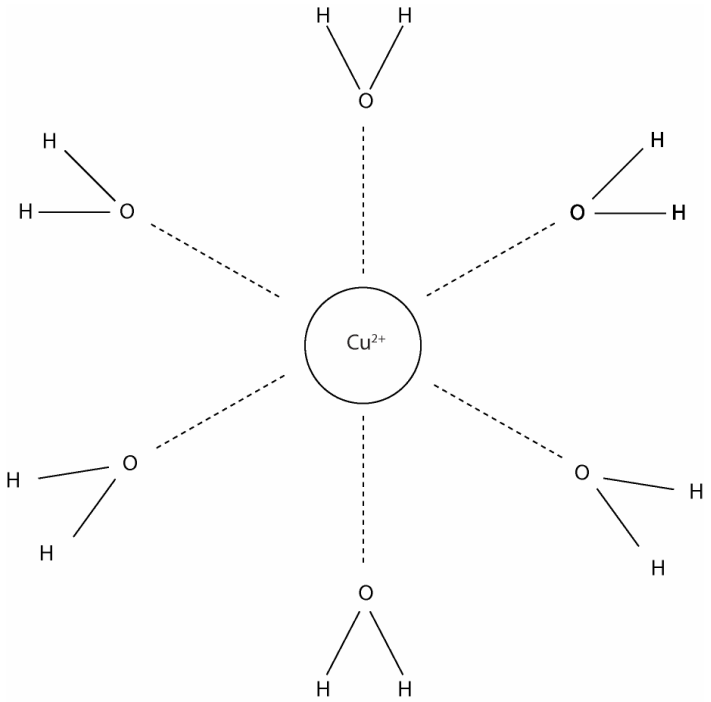
The d subshell can hold up to 10 electrons.*

1 mark

8b. Solid copper sulfate exists in a hydrated form with the formula $CuSO_4.6H_2O$. The solid contains the hydrated ion $Cu(H_2O)_6^{2+}$.

8b. i. Sketch the structure of $Cu(H_2O)_6^{2+}$, showing the arrangement and orientation of the water molecules around the copper ion.

Answer



Marks

- *1 mark is awarded for the array of six water molecules around the Cu^{2+} ion.*
- *1 mark is awarded for the correct orientation of water molecules, that is, the attraction of Cu^{2+} is to the oxygen atom, which has the negative dipole.*

8b. ii. Name the type of bonding that exists between the Cu^{2+} ion and the water molecules.

Answer

ion-dipole bonds*

8b. iii. Name the type of bonding that exists within the water molecules.

Answer

covalent bonds*

2 + 1 + 1 = 4 marks

8c. Give the subshell ground state electronic configurations for the cobalt (Co) atom and the Co^{2+} ion in terms of shells and subshells.

Answer

Co $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7 4s^2$*

Co^{2+} $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7$*

2 marks

Tips

- *The atomic number of Co, 27, is obtained from the periodic table. As the atomic number is 27, the neutral atom contains 27 electrons.*
- *Remember that electrons fill the 4s subshell before the 3d subshell because, when empty, the 4s subshell is slightly lower in energy than the 3d subshell.*
- *The Co^{2+} ion has two fewer electrons than the Co atom.*
- *Remember that, when occupied, the 4s subshell has slightly higher energy than the 3d subshell, so it loses its electrons first.*

Total 7 marks

Question 9

Write balanced equations to demonstrate each of the following reactions.

9a. a zwitterion reacting with excess hydroxide ions

Answer

$^{+}H_3NCHZCOO^{-}$*(aq) + OH^{-}(aq) → $H_2NCHZCOO^{-}$(aq) + H_2O(l)*

2 marks

Tips

- *Remember that a zwitterion is a dipolar ion. A proton has been lost from the acidic carboxyl group and accepted by the basic amino group.*
- *On the amino acid molecule $NH_2CHZCOOH$, the NH_2 end is basic and the COOH end is acidic.*
- *On the zwitterion $^{+}H_3NCHZCOO^{-}$, the NH_3^{+} end is acidic and the COO^{-} is basic.*
- *In a basic solution, a zwitterion will act like an acid and donate a proton from its NH_3^{+} group.*

9b. the formation of carbon by nuclear reaction in stars

Answer

$^{8}_{4}\text{Be} + {}^{4}_{2}\text{He} \rightarrow {}^{12}_{6}\text{C}^*$

OR

$3\ {}^{4}\text{He} \rightarrow {}^{12}\text{C}^*$

1 mark

9c. aluminium oxide reacting with excess hydrogen ions

Answer

$Al_2O_3(s) + 6H^+(aq) \rightarrow 2Al^{3+}(aq) + 3H_2O(l)^*$

1 mark

Tips

- *Al_2O_3 is an amphoteric oxide, that is, it reacts in acidic solution and basic solution.*
- *An equation showing aluminium oxide reacting with excess hydroxide ions is $Al_2O_3(s) + 2OH^-(aq) + 3H_2O(l) \rightarrow 2Al(OH)_4^-(aq)$*

Total 4 marks

END OF SOLUTIONS