T A S M A N I A N

S E C O N D A R Y

A S S E S S M E N T

B O A R D

SC786

Physical Sciences

2002 External Examination Report

General Comments

Each year the external examination shows there is a group of very capable candidates who, on completion of this course, can demonstrate excellent skills in all areas. There is also a significant number of candidates attempting the external paper who have little or no idea about any concepts studied in this course. This latter group has little competence when solving basic algebraic equations in both the Physics and Chemistry components and cannot complete even the most basic of chemical equations. It is surprising that some of these candidates had sufficient C (or better) internal ratings to be eligible to obtain a possible award at the pre-tertiary level. The exam catered quite well for this cross-section of candidates and, in particular, gave the brighter candidates the opportunity to excel.

When marking the external papers there was no real evidence to suggest candidates ran out of time. Criterion 8 was poorly done, but this was probably because of poor problem-solving skills on some candidates' part, coupled with some challenging questions.

Reviewing the borderline candidates again showed that the algorithm demanding a C (or B or A) in each of a physics and a chemistry unit for a SA (or HA or OA) prevented candidates from gaining a particular award.

The importance of completing past papers when preparing for examinations cannot be stressed enough. Each year questions are usually of a similar style and length and demand a similar knowledge base.

Criterion 7

Question 1

(a) The arrow notation used to depict the vector quantity caused confusion.

(b) Very few recognised that the expression needed was F_b - F_a.

Question 2

A statement of the law was not sufficient as an answer for these questions.

(a) Poorly done. Common errors included:
- many said this was an example of Newton's 3rd Law.
- some who identified Newton's 1st Law mistakenly said the trolley produced an unbalanced force which was why the child moved back.

(b) Many of those who chose Newton's 2nd Law got into a tangle with their explanation.
A number incorrectly used Newton's 1st Law.
Of those who chose Newton's 3rd Law, most explained well.

Question 3

Reasonably well understood.

In (c) a common mistake was to say E_k was transformed to E_p.

Question 4

(a) Better done than in previous years. Some candidates confused acceleration and force, others talked about E_k and E_p rather than forces. A surprising number had gravity's direction upwards and air resistance down. Several incorrectly interpreted the graph as the trajectory of the paper.

(b) Misinterpreted by many candidates who described what happened to the velocity and acceleration at points A, B and C. Some credit was given for this interpretation. Those who interpreted correctly often overlooked that velocity (speed) could be read directly from the vertical axis.

Question 5

(a) Generally well done with the majority of candidates illustrating that the ammeter is placed in series and the voltmeter in parallel with the resistor. If they only had a single cell in the diagram this was taken into account for Criterion 2.

(b) Well answered.

(c) A large number of candidates gained full marks by stating that the voltmeter's high resistance stopped much current flowing through it and ammeter's low resistance allowed it in series without influencing the current.

Question 6

Candidates found this question difficult. Few were able to work through to the correct conclusion. As (e) was sequential, marks were awarded for any sensible answer that illustrated knowledge of an electrical circuit. Candidates were not penalised for failing to interpret the question correctly.

Question 7

(a) Well done.

(b) Few were able to deduce ${}^{2}_{1}\mathrm{H}$ (${}^{2}_{1}\mathrm{D}$) or ${}^{1}_{1}\mathrm{H} + {}^{1}_{0}\mathrm{n}$ as possible correct answers.

Question 8

(a) The candidates were often confused as to what was expected. Any indication of inaccuracy was sufficient to gain 1 mark but the random nature of radioactivity had to be mentioned for the second mark. Many tried to compare carbon-14 with tritium.

(b) The wording of this question resulted in the acceptance of any reasonable indication that candidates knew that two half-lives had elapsed to leave _ of the original sample.

(c) Most candidates were able to illustrate the fact that tritium could be more useful for more recent artefacts and that a more accurate answer could be calculated.

Criterion 8

It was evident that many candidates struggled with the numerical section of the course.

Question 9

(a) Generally well done although there were many basic algebraic and numerical errors, such as forgetting to square numbers in the formula or even multiplying by 2.

(b) Some candidates failed to realise that g and the initial velocity were in opposite directions and hence calculated incorrectly that the rock went faster upwards with time - without comment!

(c) The majority of candidates used $F = \frac{m(v - u)}{t}$ which, if used correctly, gave the correct answer. Markers were surprised by the number using this approach because using F = ma is much easier.

Question 10

(a) Many candidates confused directions and a high proportion could not calculate the hypotenuse of the triangle.

(b) There is still confusion over the difference between speed and velocity. Units caused problems. One candidate had his competitor moving at 13 000 km/hr. Candidates are expected to comment on obviously incorrect answers.

(c) Many candidates did not realise the displacement was 3 km and failed to give a direction.

Question 11

Candidates either answered this question well or very poorly.

Question 12

The background count caused confusion and many candidates ignored it - or added it - or divided by it! The variety of graphs, scales, etc was surprising. Only a small proportion could accurately read the half-life of 30 minutes.

Question 13

(a) Well done by most. Some candidates did not convert mass to kg or did not convert to an acceleration of 25 000 m s^{-2}.

(b) Reasonably well done by most candidates. Some had difficulty, confusing vertical and horizontal components of motion.

(c) Well done, apart from the few candidates who failed to realise that the horizontal speed was constant.

If candidates used the time and range formula in (b) and (c) it often resulted in the incorrect answer and no marks were awarded. Candidates who approached these sections logically by considering vertical and horizontal components scored well.

Question 14

Many candidates did not convert km/hr to m/s, otherwise well done.

Question 15

(a) Many candidates did not calculate both the E_p and E_k.

(b) Setting out was poor. Some attempted to use the equations of motion formula instead of energy considerations to solve the problem.

(c) Poorly done.

(d) Poorly done. Most candidates were unable to choose the right approach, based on energy, to solve this question.

Criterion 9

Question 16

Quite well answered, with the formulae of ions being the most poorly answered part of the question. Some candidates left it unanswered, some included ratios of ions present as part of their answer and some gave just the charge on the ions.

Question 17

(a) Generally good.

(b) Good efforts, with most candidates recognising that both elements were in group 5, had 5 electrons in the outer shell and needed 3 more for a full outer shell. Only a few candidates considered that the full outer shell could also be attained by sharing electrons with other elements to form a covalent bond. Most just considered the receiving of 3 electrons to form an ionic compound. Terminology was generally satisfactory.

Question 18

Well answered. A few candidates calculated relative atomic mass, even though it was not required for full marks. Some thought Ne occurred naturally as ^{20}Ne and that ^{22}Ne was its isotope! Some candidates incorrectly introduced radioactivity into their answer.

Question 19

Good. When completing the table in the last line many candidates selected oxygen as the answer rather than hydrogen chloride. In the discussion in b) candidates correctly sited that some structures share similar properties, with only a few commenting that there are exceptions to the general characteristics for a class of compounds (eg mercury).

Question 20

(a) Many wrote about water being amphiprotic and didn't answer the question.

(b) Many candidates fail to understand that pH decreases as concentration of the acid increases. The best answers resulted when candidates discussed the degree of dissociation as indicated by the different pH values at the same concentration.

(c) Water dilutes the acid until it is nearly pure water with a pH of approximately 7. Water does not neutralise the acid.

Question 21

Each idea needed to be addressed. ie. bonding type, relevance to furnace bricks and sandpaper.

Question 22

Well done except for many candidates failing to count the number of atoms correctly.

Question 23

(a) A significant number of candidates failed to realise that the double bond gets the lowest number in naming.

(b) Candidates showed confusion as to what isomers really were. Both chemical and physical properties will differ.

(c) Many candidates included compound A drawn the other way around as an isomer.

(d) The equation for polymerisation was poorly done. The monomers add across the double bond and the CH_2Cl group as a side chain.

Criterion 10

Questions 24 – 28

In short, the results were disappointing. Many candidates seemed ill prepared for these questions, even though similar questions are asked every year.

Common errors included:
- inability to balance simple equations.

- failure to correctly distinguish between atoms, ions and molecules.
- failure to realise that ionic compounds are not molecular.
- failure to realise that an equation can only be written if a reaction occurs and that juggling symbols will not make the "reaction" take place!
- hydrogen being a product of the combustion of a hydrocarbon.
- failure to refer to the "cheat sheet" to determine solubilities or the general formula of an alkyne.
- confusion over the meaning of "dissociates"

Question 29

Generally well done. Common errors were:

- ignoring the percentage of oxygen in the compound and working out the empirical formula for S and Ca only.
- finding the correct ratio then writing the formula out in the wrong order ($SCaO_3$) and then giving it the wrong name.

Question 30

Well done.

Question 31

Some candidates did not realise that the amount of NaOH needed could be found by using

$$n(NaOH) = c(NaOH) \times V(NaOH).$$

Most candidates correctly found M(NaOH) and were able to use $m = n \times M$.

Question 32

(a) & (b) Well done. Some candidates missed the sixth hydrogen atom (in the hydroxy group).

(c) Many candidates tried to find the number of hydrogen atoms rather than the number of moles of hydrogen atoms.

(d)

(d) Poorly answered. The use of Avogadro's Number caused confusion with many candidates multiplying by it rather than dividing.

Question 33

(a) Well done.

(b) Many candidates did not realise this was a simple reaction ratio problem and they tried to use n = c x V.

(c) Generally well done but many algebraic and numerical errors were made. eg. 0.02 became 0.2.

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SOLUTIONS TO THE 2002 SC786 PHYSICAL SCIENCES EXAM

CRITERION 7

Question 1:

a) West.

b) Assuming the diagram is drawn to scale, F_b -F_a, is the magnitude of the resultant force. In vector notation, this is $\underline{\mathbf{F}_a} + \underline{\mathbf{F}_b}$. In scalar notation this is $F_b - F_a$.

Question 2:

a) According to *Newton's First Law of Motion*, the child tends to remain at rest (*inertia*) whilst the trolley accelerates forwards under the action of the applied resultant force.

b) *Newton's Third Law of Motion* states that if body **A** pushes on body **B**, **B** pushes equally on body **A** in the opposite direction. The air is pushed out of the balloon by the balloon contracting so causing the balloon to be pushed in the opposite direction. This air rushing out of the flexible neck of the balloon constantly changes the direction that its neck points, so causing the balloon to fly erratically around the room.

Question 3:

a) Frictional forces in the opposite direction to the car's motion, between the road and the car and the air and the car.

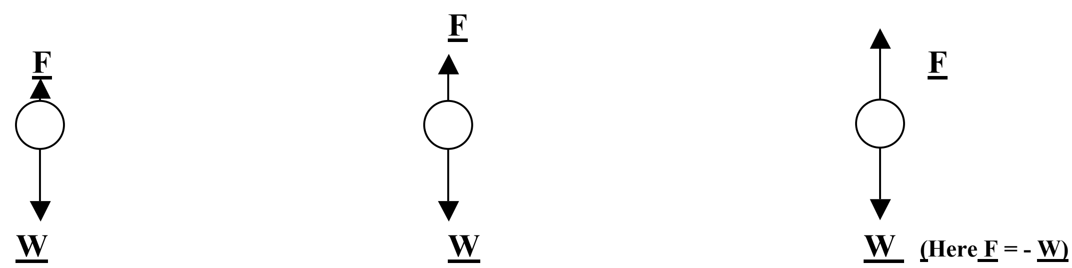
b) This is not an "isolated system". The momentum of the car given to the Earth and the surrounding air.

c) Converted into heat and sound.

Question 4:

Let $\underline{\mathbf{F}}$ represent the upward force of air resistance and $\underline{\mathbf{W}}$ represent the weight of the piece of paper.

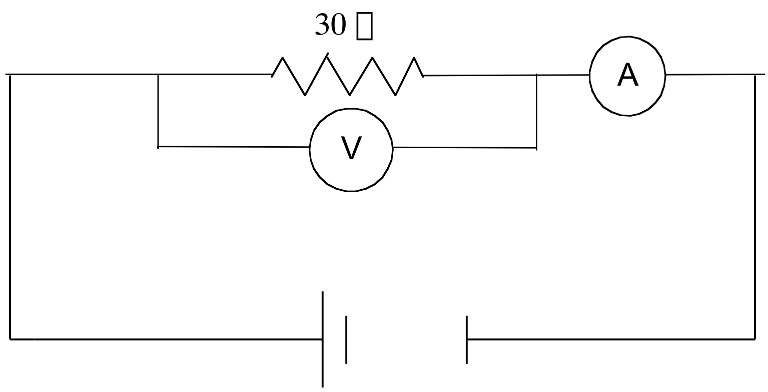
a) At Point A ($F < W$) At Point B ($F < W$) At Point C



b) The displacement of the paper can be measured by measuring the area under the v~t graph. The velocity of the paper at a particular time can be measured by finding the velocity corresponding to that time from the graph. The acceleration of the piece of paper at an instant can be measured by finding the gradient of the graph at that time. ($a = \Delta v/\Delta t$)

Question 5:

a)



b) the same as

c) An ammeter would alter the current in the resistor if the ammeter had an appreciable resistance. This would be equivalent to having an additional resistor in series with the 30 _. The voltmeter would “short-circuit” the resistor if it had no resistance. Because of its high resistance, a voltmeter draws only a very small current. The higher the resistance of the voltmeter the better it is for measuring the potential difference across the resistor.

Question 6:

If R_t is the total resistance, then:

$1/R_t = 1/R_3 + 1/(R_1 + R_2)$

a) Decreases.

b) Decreases.

c) Decreases.

d) Stays the same.

e) R_1 and R_2 would be in the same parallel branch of the circuit and are connected in parallel across each other. Thus they would be subject to the same potential difference

Question 7:

a) ${}_{2}^{4}He$ (an alpha particle)

b) ${}^{133}_{58}Cs + {}_{o}^{1}n \rightarrow {}^{132}_{54}Xe + {}_{1}^{2}H$

Thus X is ${}_{1}^{2}H$ (deuterium atom)

Question 8:

a) There is considerable uncertainty in the measurement of the half-life of carbon-14. The given half-life is accurate only to 3 significant figures.

b) 11 310/5 730 $\approx$ 2 half-lives, so _ of the original amount is left.

c) Tritium has a very short half-life compared to carbon-14. It would only be useful for dating an object that was died some 4 or 5 half-lives ago. After 11310 years the amount of tritium remaining would be 12.3/(11 310) of the original, which is an insignificant amount.

CRITERION 8

Question 9:

a) $\underline{\mathbf{u}} = 27\ ms^{-1}$_, $\underline{\mathbf{v}} = 0$, $\underline{\mathbf{a}} = 9.8\ ms^{-2}$_

$v^2 = u^2 + 2as$

∴ $0 = 27^2 + 2 \times -9.8 \times s$

∴ $s = 37.2\ m$

b) **(i)** $\underline{\mathbf{v}} = \underline{\mathbf{u}} + \underline{\mathbf{a}}t$

$= 27 – 9.8 \times 1$

$= 17.2\ ms^{-1}$_

(ii) $\underline{\mathbf{v}} = \underline{\mathbf{u}} + \underline{\mathbf{a}}t$

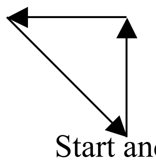
$= 27 –9.8 \times 4$

$= -12.2\ ms^{-1}$_

$= 12.2\ ms^{-1}$_

c) As air resistance is ignored, the only force acting on the stone after its release is its weight, which is the pull of gravity on the stone and is also the unbalanced force, which acts on it. $\underline{\mathbf{W}} = m\underline{\mathbf{g}} = (0.12 \times 9.8)$ N_ = 1.18 N_ This is the force acting at 1.00 s and 4.00 s.

Question 10:



Start and finish

The above vector diagram forms a right-angled isosceles triangle.

a) Average speed = s/t =(3 + 3 + √18)/45 = 0.228 km/min =3.79 m s^{-1}

b) Average velocity (measured from the start) = 0 because the displacement of the competitor is zero as he/she returns to the starting point.

c) Average velocity = displacement/ time taken = 3 km/30 min = 0.100 km/min = 6.00 km h-1 N 45^0 W.

Question 11:

a) $V_{20\Omega} = I_{20\Omega}R_{20\Omega} = 0.45 \times 20 = 9.00V$. This is also the voltage of the battery.

b) R = V/I =9.0/0.30 = 30.0 **Ω**

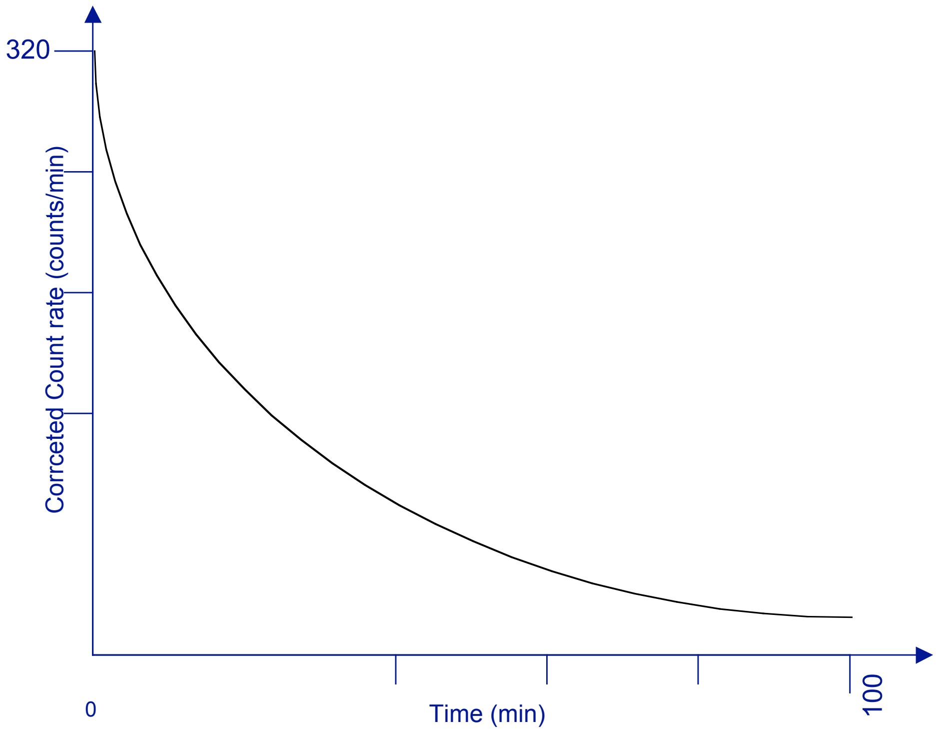
c) $I_t = 0.30 + 0.45\ A = 0.75\ A$

Q = It

∴ t = Q/I = 900/.450 = 2000 s =33 min 20 s

Question 12:

a)



Subtracting the background count from the actual count rate to obtain the corrected count, and plotting the corrected count against time shows that the time for half the activity to occur, the half-life, is about 30 minutes.

Question 13:

a) $m = 0.045$ kg, $F=1\ 125$ N, $t = 0.0020$, $s = 0$

$F = ma = m(v-u)/t$

$1125 = 0.045v/0.0020$

$\therefore v = 50.0 \text{ m s}^{-1}$

b) In the vertical direction, using $s = ut + 0.5\ at^2$

$\therefore\ 0 = 50 \sin 25^0\, t - 4.9t^2$

$\therefore\ t = 50 \sin 25^0/4.9$

$= 4.31$ s

c) In the horizontal direction, and since the horizontal component of the ball's initial velocity remains constant,

$s = vt$

$= 50 \cos 25^0 \times 4.31$

$= 195.3$ m

Question 14:

(a) Momentum of boat just before Jet Ski arrives = (500 x 10) kg m s^{-1} S = 5000 $kgms^{-1}$ S

(b) Combined momentum of boat, jet ski and stuntman after Jet Ski arrives = (750 x 11.67) kg ms^{-1} S = 8 752.5 kg m s^{-1} S

(c) Total momentum before Jet Ski arrives = total momentum after it has arrived. If v ms^{-1} is the speed of the Jet Ski just before it arrives:

□ 250v + 500x10 = 8752.5

□ v = 3752.5/250 = 15.0 m s^{-1}

So the velocity of the Jet Ski is 15.0 m s^{-1} S.

Question 15:

a) $E_t = E_p + E_k$
= mgh + _ mv^2
= (500 x 9.8 x 30.0 + _ x 500 x 1.50^2) J
= 147 562.5 J = 1.47 $x10^5$ J

b) Loss in E_p at C = gain in E_k at C = (500 x 9.8 x 5) J = 24 500 J
E_k at C = (562.5 + 24 500) J = 25 062.5 J
□ v^2 = 25062.5 x 2/500
□ v = 10.0 m s^{-1}

c) W = mg = (500 x9.8) N = 4 900 N
□ F_r = (4 900/5) N = 980 N (frictional force)

d) Energy lost due to friction in getting to B = work done = Fs = (980x 67) J = 65 660 J

E_k at B = (147 562.5 – 65 660) J = 81 902.5 J
Since $v^2 = 2E_k/m$
□ v = 18.1 m s^{-1}
The speed is 18.1 m s^{-1}

CRITERION 9

Question 16:

Silver oxide	Ag^+, O^{2-}	Ag_2O
Lead (IV) chloride	Pb^{4+}, Cl^-	$PbCl_4$
Calcium hydrogen sulfate	Ca^{2+}, HSO_4^-	$Ca(HSO_4)_2$

Question 17:

a)

${}_{15}^{31}P$	15	16	15	2, 8, 5
${}_{15}^{30}P^{3-}$	15	15	18	2, 8, 8
${}_{7}^{14}N$	7	7	7	2, 5

b) Both phosphorus and nitrogen are in Group 15 of the periodic table. These two non-metallic elements each have 5 electrons in the outer shells of their atoms. Both elements form $^{3-}$ ions with some difficulty. Both elements react with hydrogen to form covalent molecular compounds with similar molecular formulae, PH_3 and NH_3.

Question 18:
Neon occurs in 2 isotopic forms of mass numbers 20 and 22. Neon-20 is about 7 times more abundant than neon-22.

Question 19:

a) The unfilled boxes are mercury, (metallic), ***either silicon dioxide or diamond***, (covalent network), sodium chloride, (ionic), hydrogen chloride,.
b) Different structures share common properties. For example, metallic, and ionic structures both conduct electricity in the liquid (molten states). Most metals, ionic compounds and covalent network elements and compounds have high melting points.

Question 20:

a) Using the Bronsted-Lowry theory of acidity, a water molecule accepts a proton from an acetic acid molecule.
b) Stronger acids have a lower pH at the same concentration (molarity). Thus hydrochloric acid is the stronger acid.
c) The upper limit would be a pH of 7. However, this would only theoretically occur at infinite dilution. The pH would increase, but not uniformly, as the solution became more dilute.

Question 21:
Aluminium oxide, Al_2O_3, an ionic compound, is used as a ceramic. It has a very high melting point due to strong electrostatic attractions between the Al^{3+} and O^{2-} ions in the crystalline lattice. These strong bonds prevent the ions form being dislodged from the crystalline lattice when aluminium oxide is used as an abrasive.

Question 22:
HC _ C-CH_2-CH_3 C_4H_6 but-1-yne
$C_6H_{13}Cl$ 1,3-dichloro-3-methylpentane

Question 23:

a) **A** is 3-chloroprop-1-ene, **B** is chlorocyclopropane.
b) **A** and **B** have the same molecular formula, C_3H_5Cl
c) $ClCH_2 = CHCH_3$, (1-chloroprop-1-ene) and $CH_2 = CClCH_3$ (2-chloroprop-1-ene)
d) **A** could be used to make a polymer as it can undergo addition polymerisation. It acts as the monomer and is an unsaturated molecule. Addition polymerisation only takes place with unsaturated compounds. During addition polymerisation the double bond opens in each molecule of C_3H_5Cl leaving an unpaired electron on each of the 2 carbon atoms that were joined by the double bond. Under the right conditions of temperature and pressure, and with the presence of a suitable catalyst, addition polymerisation will take place with the C_3H_5Cl molecules forming a long chain polymer.
The repeat unit in the polymer chain that is formed is -$CH_2CH(CH_2Cl)$-

CRITERION 10

Question 24:

a) $Fe_2O_{3(s)} + 3CO_{(g)} \rightarrow 2Fe_{(l)} + 3CO_{2(g)}$
b) $2Mg_{(s)} + O_2(g) \rightarrow 2MgO_{(s)}$

Question 25:

a) $Zn_{(s)} + 2HCl(aq) \rightarrow ZnCl_{2(aq)} + H_{2(g)}$
b) A colourless gas is evolved. There may be an odour because of the acid spray, and the zinc gradually disappears. A colourless solution is formed. The reaction is exothermic.

Question 26:

Add a few drops of the $HCl_{(aq)}$ to the suspected carbonate. If effervescence occurs and a colourless, odourless gas is evolved the mineral is almost certainly a carbonate. *(A limewater test would be required to determine this beyond all doubt.)* The mineral should be brown in colour and sparingly soluble. However, not all brown, sparingly soluble minerals are iron (II) carbonate!
$FeCO_{3(s)} + 2HCL_{(aq)} \rightarrow FeCl_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$

Question 27:

The differences observed are due to incomplete and complete combustion in the cases observed. Complete combustion gives the clear flame. The sooty flame is caused by the presence in it of tiny particles of solid carbon. It is also possible that either or both carbon monoxide and carbon dioxide are formed with the elemental carbon in an incomplete combustion reaction.

Incomplete combustion: $2C_2H_{2(g)} + O_2(g) \rightarrow 4C_{(s)} + 2H_2O_{(g)}$
Complete combustion: $2C_2H_{2(g)} + 5O_{2(g)} \rightarrow 4CO_{2(g)} + 2H_2O_{(g)}$

Question 28:

a) $BaCl_{2(s)} \rightarrow Ba^{2+}{}_{(aq)} + 2Cl^{-}{}_{(aq)}$
b) $M(BaCl_2)) = (137.3 + 2 \times 35.5) = 208.3\ g\ mol^{-1}$
$M(KCl) = (39.1 + 35.5) = 74.6 = 74.6\ g\ mol^{-1}$
Thus the barium chloride would have the greatest mass for the same amount (molar quantity).
c) Based on equal amounts, the barium chloride solution would contain the greatest number of ions as it has 3 moles of ions for each mole of compound, whilst the potassium chloride has only 2 moles of ions for each mole of compound. There would be comparatively small but equal numbers of $H^{+}{}_{(aq)}$ and $OH^{-}{}_{(aq)}$ ions in both beakers because the same volume of water has been used in each case.
d) $BaCl_{2(aq)} + Na_2SO_{4(aq)} \rightarrow BaSO_{4(s)} + 2NaCl_{(aq)}$ A precipitate of barium sulfate is formed as an insoluble combination of ions is present in the mixture..
$BaCl_{2(aq)} + KCl_{(aq)} \rightarrow$ no precipitate, and a clear solution remains.

Question 29:
Take 100.0 g of the compound.

	S	Ca	0
Mass ratio	26.7	33.4	38.9
Mol ratio of combined atoms	26.7/32.1	33.4/40.0	38.9/16.0
	0.832	0.835	2.43
	1.0	1.0	3.0

Thus the empirical formula is $CaSO_3$ (calcium sulfite).

Question 30:
There are 18.0 mol in 1000 mL of 18.0 mol L^{-1} H_2SO_4.
2500 mL of 1.50 mol L^{-1} H_2SO_4 contains (1.5 x 2.5) = 3.75 mol
Vol required = (1000/18) x 3.75 = 208.3 mL

Question 31:
M(NaOH) = 40.0 g mol^{-1}
Amount required = 1.5 x 1.5 mol = 2.25 mol
 Mass of NaOH required = (40 x 2.25) g = 90.0 g

Question 32:
a) $M(C_2H_5OH)$ =12.0 x2 + 5 x 1.0 x 16.0 + 1.0 = 46.0 g mol^{-1}
b) % hydrogen by mass = (6.0/46.0) x 100 = 13.0 %
c) There are 6 mol of hydrogen atoms in 1 mol of ethanol.
d) 6.02×10^{23} molecules of ethanol weigh 46.0 g. Thus 1 molecule weighs $46.0/(6.02\times10^{23})$ g. This is 7.64×10^{-23} g.

Question 33:
a) c =n/v, v = n/c = (0.020/0.100) x 1000 mL = 200.0 mL
b) 2 mol NaOH reacts with 1 mol H_2SO_4
 2 x 0.020 mol NaOH reacts with 0.020 mol H_2SO_4 = 0.400 mol
c) Amount of Na_2SO_4 formed = 0/0200 mol
$M(Na_2SO_4)$ = (2 x23.0 + 32.1 + 4 x16.0) = 142.1 g mol^{-1}
 m (Mass of Na_2SO_4 formed) = nM = 0.0200 x 142.1 = 2.84 g