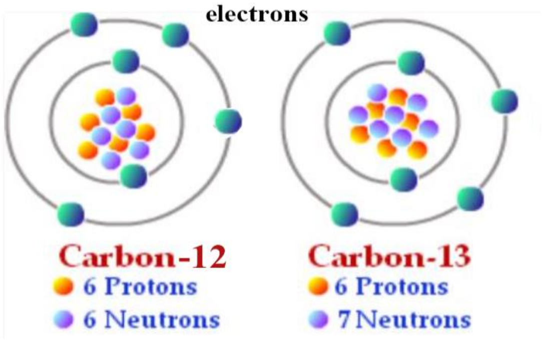
2024 ASSESSMENT REPORT
PSC315118 PHYSICAL SCIENCES

Section A – Criterion 4

Question 1

a)



Marking Details

0.5 marks was allocated for each of number of protons, electrons and neutrons, when correct, in each diagram (total 3 marks).

1 mark was allocated for use of a key or another suitable way to interpret diagrams.

b)

i. They have different numbers of neutrons (C-12 has 6 whereas C-13 has 7).

ii. Both isotopes have 6 protons and 6 electrons.

Marking Details

Half marks were allocated for i) when the different numbers of neutrons were not stated (6 versus 7) if this was not apparent in 1a) diagrams.

c) % C-14 = 100 – (35.5 + 20.0) = 44.5%.

RAM = 0.355 x 12 + 0.20 x 13 + 0.445 x 15 = 13.1.

Marking Details

0.5 marks were deducted for each calculation error.

1 mark was allocated where C-14 was not included in an otherwise correct calculation.

d) All carbon atoms have 6 protons.

Marking Details

0.5 marks was deducted for failure to state the number of protons is 6 (i.e. just mentioning protons).

TASMANIAN ASSESSMENT, STANDARDS & CERTIFICATION

e) ${}^{14}_{6}C \rightarrow {}^{0}_{-1}e + {}^{14}_{7}N$

Marking Details

0.5 marks were deducted for each error.

General Comments

Overall, quite well done as the question covered basic foundational understanding.

a) Diagrams needed to have a key or labels for their model. Protons and neutrons needed to be shown in the nucleus.

A common mistake to have three orbits with 12 and 13 electrons as well as 12 and 13 neutrons.

Some students drew negative symbols in a circle for neutrons, some drew crosses in the orbits to indicate electrons (could appear like + signs). Electrons should not be paired in model unless over 4 (no penalty was applied for this). Models needed to indicate the total number of electrons, not just valence electrons.

b)

i. Stronger responses referred to specific numbers shown in their models rather than writing "different number of neutrons".

ii. Again, stronger responses referred to specific numbers in the model rather than "same number of protons and electrons".

Markers accepted electron configuration and a combination of 2 electron shells and 4 valence electrons as correct similarities.

c) A significant number of students forgot to calculate C-14 percentage and that the relative abundances must add up to100%. Some students didn't recognise that the answer should have been between 12 and 14.

d) For full marks, students needed to have '6 protons' not just 'protons'.

e) A variety of errors resulted from a failure to balance masses and charges. Reversal of equations was relatively common with decay products on the left-hand side.

Question 2

a) Li < Mg < Na < K

Marking Details

0.5 marks deducted for missing an element or having Na before Mg.

b)

- Moving down a Group there are more electron shells, and this pushes the valence shell further from the nucleus.
- There is also less electrostatic attraction between the nucleus and the valence shell. This increases the atomic radius. Hence, lithium is smaller than sodium, which is smaller than potassium.
- Moving across a period, the number of protons increases but the number of full electron shells is constant; the nuclear charge is shielded from the valence shell equally.
- Hence the electrostatic attraction between the nucleus and the valence shell increases moving across a period, and the radius decreases. This is why Mg is smaller than Na.

Marking Details

Full marks required explanations that referenced weaker electrostatic attraction as additional electron shells are added (hence larger radii) AND increased electrostatic attraction with additional protons in the nucleus.

Marks were deducted for attributing additional electrostatic attraction to greater electron numbers/shells.

c) Mg^{2+} 2, 8, 2.

Marking Details

Some credit was given for Mg^{+} with 2,8,1, but students are encouraged to use examples listed on the information sheet.

d) 2, 8.

e) Na^{+}.

Marking Details

No credit was given for Ne (not an ion) Partial credit for ions with the same electron structure but not included in the list for Q2.

General Comments

Overall, most students showed understanding of periodic table trends and the relationship between electron configuration and ions.

a) A significant number of students failed to include potassium in their answer. Half marks were awarded for having two in the correct position.
b) No marks given for simply restating the trends from the information sheet. Students need to be reminded to justify in terms of atomic structure and include specific values (e.g. electron shells and protons).
c) Well done by most students.
d) Most students referenced Mg^{2+} (as per information sheet) with the correct electron configuration (2, 8, 2).
e) Generally well done. Some students did not use the elements stated above. Neon was not given any marks but F^{-}, O^{2-}, Al^{3+} were given half marks.

Question 3

a) ${}^{239}_{94}Pu + {}^{1}_{0}n \rightarrow {}^{240}_{95}Am + {}^{0}_{-1}e$.

Marking Details

0.5 marks were deducted for each error.

b) ${}^{239}_{94}Pu + {}^{4}_{2}He \rightarrow {}^{242}_{96}Cm + {}^{1}_{0}n$.

Marking Details

0.5 marks were deducted for each error.

c)

- Neutrons are neutrally charged and hence there are no repulsive forces between them and the positively charged nucleus.
- As a result, accelerating the neutrons to high speeds is not necessary.
- Alpha particles, like the nucleus, are positively charged.
- To overcome the repulsive forces between the nucleus and the alpha particle, large speeds are required before collision.

Marking Details

1 mark allocated for describing the charges of the 2 particles.

1 mark allocated for relating the required speed to the need to overcome nuclear repulsion.

d) Shield workers from radiation by having them wear a lead-lined apron when working with the radioisotopes.

Use tongs or robotic arms to maintain a larger distance from the radioisotope when workers are manipulating it.

Leave the nuclear laboratory space, or place radioisotopes in storage, as soon as testing is completed to minimise the time workers are exposed to the radioisotope.

Marking Details

Half marks were awarded for general reference to increasing distance, using shielding and decreasing time spent around radiation.

0.5 additional marks were awarded for each practical example of ways to implement these general rules.

General Comments

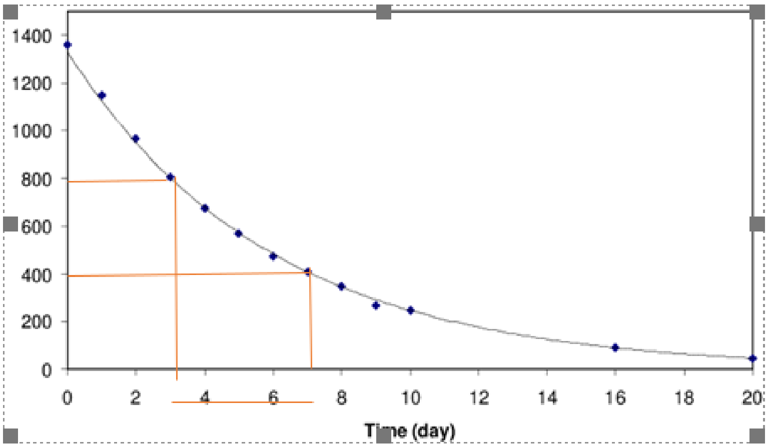
Overall, students need to take care when writing element symbols and isotopic notation as some symbols and numbers were wrong or missing.

a) Generally well done. Three of the four species involved were given in the question, so notation became a focus. Students were inconsistent in their use of isotopic symbol formats. Those who could balance nuclear equations recognised the production of an electron.
b) Also generally well done but again, three of the four species were given in the question. Many of the incorrect responses placed the products on the left of the equation. Again, isotopic symbol formats and charge and mass symbols for smaller particles were inconsistent.
c) Discussion of properties of alpha and beta radiation was more common than recognition of the need to overcome the repulsion of the nucleus to allow alpha particles to bring about transmutation. Good responses compared the charges of the particles and related the need for speed to overcome repulsion.

This question was generally done poorly. Most students only achieved half marks due to a lack of practical applications of the DST rules. “Wear PPE” gained no credit.

Question 4

a)



7-3 = 4 days, the half-life is approximately 4 days.

b) ${}^{222}_{86}Rn \rightarrow {}^{4}_{2}He + {}^{218}_{84}Po$.

c)

- Am is a solid and, while they are highly ionising, the alpha particles emitted would be stopped by collisions with molecules in the air or contact with skin so they cannot penetrate into the body.
- Rn is a gas and can be easily inhaled. Thus, Rn can decay in the lungs producing alpha particles in a location where they would damage lung tissue.
- Radon's shorter half-life results in a higher activity with many more decays and alpha particles produced relative to Am-241 in a given period.

Marking Details

1 mark allocated for making first point.

1 mark for second point.

1 mark for third point.

d) After 1 half-life the activity is 50%, a second half-life gives 25%, a third gives 12.5%. So, it takes 3 half-lives, or 3x432 = 1296 years.

Marking Details

1 mark deducted for calculating 4 half-lives required.

0.5 marks deducted for using $T^{1}/_{2}$ = 4 days.

General Comments

Overall:

a) Most got the half-life correct. Many didn't show adequate working on the graph although credit was given for anything that showed halving. 0.5 marks were deducted if 1400 and 700 were used.

b) Well done by the majority of students.

c) Poorly done by many students.

Most students generally identified one of the three elements we were looking for.

Reference to half-lives need to relate to decay activity.

d) Well done by most students.

A common error was using 4 days ($T^1/_2$ for Rn-222) instead of using 432 years for Am-241. Others halved correctly but counted 4 rather than 3 half-lives.

Some students calculated 12.5% of the initial count, then calculated the required time. This was an unnecessary step.

Section B – Criterion 5

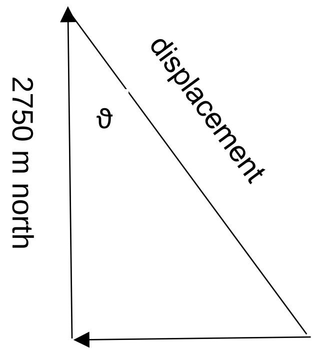
Question 5

a) Average speed = total distance/total time
= (1500 + 2750) / (1200 + 2300)
= 4250 / 3500 = 1.21 m s^{-1}

Marking Details

0.5 marks deducted for each error in calculation.

b)



Using Pythagoras' Theorem:

Displacement = $(2750^2 + 1500^2)^{1/2}$
= 3130 m

Angle θ tan θ = 1500/2750 = 0.5454
So θ = 28. 6^0
Displacement = 3130 m N 28.6^0 W

Marking Details

1 mark for diagram.

1 mark for correct calculation of the magnitude of displacement.

1 mark for statement including units and a bearing.

c) Leaving 45 minutes later means leaving 15x600 = 2700s later
Total travel time for speedboat
= 1200+2300-2700 = 800 s

Velocity = Displacement / time
= 3130 /800 m s^{-1}
= 3.91 m s^{-1} at a bearing of N 28.6^0 W.

Marking Details

Some credit was given for velocity calculations using 2700 seconds.

Marks were deducted where no direction was given.

W61.4ºN was also accepted.

General Comments

Overall, reasonably well done.

a) This question was mostly done well. Many students used the correct method but prematurely rounded off to 1ms^{-1}.

b) Most students recognised the need to use Pythagoras's Theorem. Some diagrams were inverted and while most students drew diagrams with arrows in the correct direction, several answers had no arrowheads so did not indicate direction at all. This led to incorrect bearings. Many students struggled to appropriately convert the angle they calculated to a bearing (either relative to North or a true bearing). Markers accepted any correct version, but it should be noted that W61°N ≠ N61°W.

c) Many students used 2700s as travel time rather than subtracting it from the time calculated in part a). This led to errors in the calculated velocity. Others did not include a direction/bearing for velocity.

Question 6

a) Diver is freely falling so u = 0ms^{-1} , a = 9.81ms^{-2} down , s = 1.55m down
Using $2as = v^2 - u^2$ $v = \sqrt{2as} = \sqrt{2\ x\ 9.81\ x\ 1.55} = 5.51\ \mathrm{m}\ s^{-1}$

Marking Details

0.5 marks deducted for each error in calculation.

b) Change in momentum Δp
$\Delta p = p_f - p_i$
p_f = 0.5 x 85.5 = 42.9 kgms^{-1} down
p_i = 5.5 x 85.5 = 471.9 kgms^{-1} down
Δp = 42.9 – 471.9
= - 430 kg m s^{-1} down, or 430 kgms^{-1} upwards.

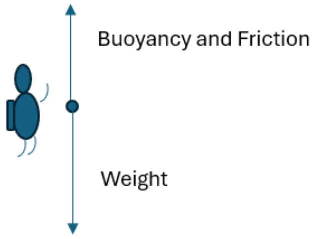
Marking Details

1 mark for calculating Δp correctly.

1 mark for a statement with the correct direction.

c)

i.



Marking Details

2 arrows required for full mark.

Weight force must be larger than upward force for full mark.

ii. Diver’s acceleration downwards = (v-u)/t
= (2.11 – 0.5) / 3 = 0.537 m s^{-2} down

Unbalanced force = ma
= 85.8 x 0.537 = 46.1 N (down).

Marking Details

Only magnitude required for full mark.

0.5 marks deducted for each error in calculation.

iii. $F_{unbalanced}$ = Buoyancy Force (up) + weight (down)
Let down be negative:
-46.1 = Buoyancy Force – 85.5 x 9.81
So, Buoyancy Force = 85.5 x 9.81 - 46.1
= 796 N up

Marking Details

1 mark for calculating the weight force.

1 mark for calculating the buoyancy force.

General Comments

a) Student responses were mostly correct, but many prematurely rounded their calculation to the given approximation.

b) Most students correctly calculated the magnitude of momentum, but many did not recognise the direction as upwards, or failed to give direction at all.

c)

i. The weight arrow needs to be longer than the buoyancy arrow. These should radiate from the centre of mass.

ii. Students who provided another vector diagram were more likely to recognise that the net force was the result of the sum of the 2 relevant forces and get the correct answer for this part. i.e., conceptual understanding is assisted by good diagrams.

Some students mixed up sections ii. and iii., calculating the answer to ii. in section iii. after failing in the earlier part. Students may be failing to understand that “the unbalanced force” is the same as F_{net}. Markers rewarded the student’s physics ability somewhere within these two sections.

Incorrect data values taken from earlier sections were used by some students when the relevant data was included in this section. Some students calculated acceleration rather than force and some students gave weight rather than downwards force or muddled the vector calculations.

Question 7

a) Height reached above the hand using

$$2as = v^2 - u^2$$

$$s = \frac{v^2-u^2}{2a} = \frac{7.75^2}{19.6} = 3.06\ m$$

Total height above the ground = 3.06 + 1.25 m = 4.31 m.

Marking Details

0.5 marks deducted for each error in substitution or calculation.

0.5 marks deducted for failing to add 1.25 m to final answer.

b) Using $v^2 = u^2 + 2as$ where s = 4.31 m

$v^2 = 0 + 2 \times -9.81 \times 4.31 = 84.6$

v = 9.20 ms^{-1} down.

Marking Details

0.5 marks deducted for each error in substitution or calculation.

c) Total time to hit the ground using:

u = 7.75 m s^{-1} up
v = 9.2 m s^{-1} down, (-9.2)
a = 9.81 m s^{-2} down
Using $t = \frac{v-u}{a} = \frac{(-9.2)-(7.75)}{-9.81} = 1.73\ s$
OR:

Time travelling upwards:	Time travelling downwards:
v = u + at 0 = 7.75 – 9.81t t = 0.79s	$s = ut + ½ at^2$ $-4.31 = 0 - 4.90t^2$ t = 0.94s

Total time = 0.79 + 0.94 = 1.73 s.

Marking Details

0.5 marks deducted for each error in substitution or calculation if this method was used.

1 mark deducted for failing to calculate both sections of travel if this method was used.

d) Newton's Second Law, the unbalanced Force acting on an object = F = ma = m (v -u)/t.

When catching the ball, an unbalanced force acts on the ball and hence, by Newton's third Law, the hand of the child. If the time of catching is made longer, then the unbalanced force is reduced. This can be done by not holding the hands rigidly but moving them downwards during the catching process.

Marking Details

1 mark for correctly stating the law.

1 mark for a valid strategy to reduce force.

1 mark for describing how the strategy increases time and/or decreases acceleration/force.

General Comments

a) This section was mostly well done, although some students missed that the ball was thrown from 1.25m above the ground. Some students completed calculations without the squares in $v^2 = u^2 + 2as$ etc.

b) This part was reasonably well done. Errors included not using u = 0 or not realising the ball fell a further 1.25 as it came down. Credit was given where errors had been carried forward from part a). Many students incorrectly used the initial velocity and displacement from the original scenario, which coincidentally gave a correct answer.

c) Most students added time up to time down, although some only found time for ½ of the journey and some used the time to reach the top and doubled it. Partial credit was given for these responses.

d) For full marks students needed to state the law, describe a valid strategy to reduce the force and fully link the proposed strategy to the law, saying why the strategy works. A significant number of students did not know what NL2 was. Some wrote entirely new laws! F=ma was given credit if the remainder of the question referenced the time taken to decelerate appropriately. Most students recognised that increasing the time would achieve the effect and talked of moving the hands down or using gloves, although many did not adequately explain the link between time, acceleration and force. Some wanted to catch the ball at a higher level or use lighter balls.

Question 8

a) Conversion to m s^{-1} from km h^{-1} requires division by 3.6 so 120 km h^{-1} = 120 /3.6 = 33.3 m s^{-1}.

b) The motion is horizontal so acceleration = 0 so,
v = distance / time = 15.5 / 33.3 = 0.465 s.

Marking Details

Partial credit for correct logic but incorrect substitution or final answer.

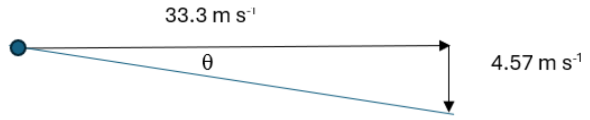
c) Vertically:
u = 0 m s^{-1} and acceleration = 9.81 m s^{-2} down.
So, v = u + a t gives
v = 9.81 x 0.465 = 4.56 m s^{-1} down.

Marking Details

0.5 marks deducted if direction not given.

Partial credit for correct calculation but incorrect substitution or final answer.

d)



Angle θ to the horizontal
$\tan \theta = 4.57 / 33.3$
$\theta = 7.8^0$ so angle to the tree is 82.2^0.

Marking Details
1 mark for diagram.

1 mark for calculation of θ.

1 mark for interpretation of angle in relation to tree.

e) Distance falls in 0.465:
$s = ½ at^2 = ½ \times 9.81 \times (0.465)^2 = 1.06$ m down.
Final Height = 12.7 – 1.06 = 11.6 m.

Marking Details
1 mark for distance fallen.

1 mark for final height calculation.

General Comments

The biggest issue with this projectile motion problem was students' failure to separate the vertical and horizontal components adequately.

a) Most correctly calculated the forward velocity though many prematurely rounded off to the approximation of $30ms^{-1}$ rather than giving the required value of 33.3.

b) Most correctly used only the horizontal values to correctly evaluate the time. Several students incorrectly used 30 in part b) rather than $33.3ms^{-1}$.

c) Some students used 0.5 rather than their calculated value for b). Some students used 33.3 as the initial vertical velocity and this impacted significantly on the answer for d). Few recorded the direction as down.

d) The lack of space for a diagram may have led to many unclear diagrams. The majority of students who did give an angle referenced the horizon. Many did not use vector arrows, and a number used displacement rather than velocities for the diagram and calculations. Calculated angles needed to be referenced as "to the tree trunk" or "to horizontal". Most students calculated the correct angle and referenced the horizontal (giving bearings was not an appropriate response and lost marks).

e) Less able students struggled with this question. A number of students added the vertical distance to the initial height of the arrow. Some tried to use trigonometry to solve the problem using the angle in d) and trig ratios to try and work out the height, which did not work.

Question 9

a)

i. Stationary when velocity = 0, 10 – 13 seconds.

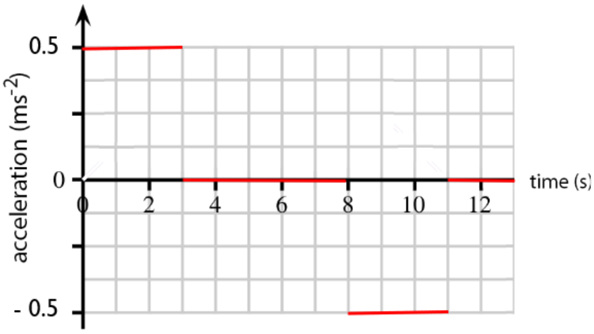
ii. Moving backwards when velocity is negative:
13 – 20 seconds.

Marking Details

0.5 marks given for a partially correct period of time.

b) 0 – 3 seconds accelerating at: 1.5 / 3 = 0.5 m s^{-2}.

8 – 11 seconds: - 1.5 / 3 = - 0.5 m s^{-2}.
No acceleration from 3 to 8 seconds and from 11 to 13 seconds.



Marking Details

0.5 marks deducted for each error.

c) Total displacement = area under the velocity graph:

= 2(½ x 1.5 x 3) + (5 x 1.5) - 2 (½ x 1 x 2) – 5 x 2 = 0 m
Total displacement = 0 m.

Marking Details

Credit was given for partially correct calculations of area.

0.5 marks subtracted for incorrect displacement units.

General Comments

Most students did this question reasonably well.

a) Students frequently misread the graph's axes so v_{max} was interpreted as 3ms^{-1} (not 1.5) and 3 seconds was often read as 2.5s. Units of time were not always stated.

i. Most students could identify stationary periods, but backward or negative velocities were confusing for them in part ii.

ii. This was less well done. Many students listed periods with negative gradients or excluded the final second of backwards motion. Other students thought backward motion began at 8 seconds when the velocity gradient became negative. Some thought the backward motion ended at 19 seconds when the gradient became positive.

b) Many students measured the slope of the graph correctly and recognised the step graph as the correct solution. Some did not show the appropriate scale. Failure to correctly read the x and y axes on the original graph led to incorrect gradient calculations. Several students displayed the negative acceleration as positive. Most students drew an acceleration graph with the correct shape, but a number of candidates calculated values incorrectly (possibly due to incorrectly reading axes in the vt graph). The period from 8 to 11 seconds was represented as a positive acceleration by some. A few continued negative motion to 12 seconds, rather than returning to zero. Some students calculated area rather than gradient for this section.

c) Few students stated that displacement could be calculated from area under the graph, but most solutions involved calculations of area. Misinterpretation of axes, incorrect formula for triangles, not recognising/subtracting negative areas also impacted many answers. The most common error was thinking the velocity between 3 and 8 seconds was $3ms^{-1}$ rather than $1.5ms^{-1}$. The other common error was a failure to subtract the second part of the motion as the velocity was negative. Some students gave units as m^2.

Section C – Criterion 6

Overall, this was a relatively straight forward and fair section, with a some more challenging questions.

It should be noted that a common error involved students using C5 SUVAT equations more than momentum and energy concepts, which cost students marks. Teachers and students need to be aware of this for future years.

In general, mathematical skills of students were lacking, with many frequently rounding values too early which significantly affected final answers.

Students are reminded to follow the “show that” instructions on the front of the paper.

Question 10

a) $p = mv$
$= 5.50 \times 10.5 = 57.75$ kg m s^{-1} North
$= 57.8$ kg m s^{-1} North. (3 sig fig)

Marking Details

0.5 marks deducted for incorrect significant figures.

b)

i. $m_1u_1 + m_2u_2 = m_3v_3$
$57.75 = 41.1v_3$
$v_3 = 1.41$ m s^{-1} North.

ii. $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$
$5.50 \times 10.5 + 0 = 5.5 \times (-2.45) + 35.6v_2$
$57.75 = -13.48 + 35.6v_2$
$v_2 = 71.23/35.6 = 2.00$ m s^{-1} North.

Marking Details

0.5 marks conservation of momentum.

0.5 marks addition of masses.

0.5 marks direction (backwards/forwards NOT accepted).

0.5 marks magnitude.

Use of 60 $kgms^{-1}$ North for initial momentum v_3= 1.46 ms^{-1} North. = 2 marks maximum.

No addition of combined masses = v_3= 1.62 ms^{-1} North/ = 1.5 marks maximum.

1 mark for identification of ball velocity as 2.45 ms^{-1} South required to be substituted as -2.45 ms^{-1}.

0.5 marks direction.

0.5 marks magnitude.

Use of 60 kg m s^{-1} North for initial momentum v_2= 2.06 ms^{-1} North = 2 marks maximum.

If ball velocity 2.45 ms^{-1} South was substituted as 2.45 ms^{-1} (no direction consideration) v_2= 1.25 ms^{-1} North = 1 mark maximum.

General Comments

Overall, this question was generally well done.

Common errors included not including direction and not making an overall statement related to the conservation of momentum.

Question 11

a) $E_k = ½mv^2$
= 0.5 x 14600 x 27.78^2
= 5.64 x 10^6 J.

Marking Details

0.5 marks equation/working.

b) Kinetic energy is converted into gravitational potential energy, OR $E_K \rightarrow E_p$.

Marking Details

1 mark.

c) At a height of 10 m, the truck's
E_p = mgh = 14600 x 9.81 x 10 = 1.43x10^6 J.

Hence the remaining
E_k = (5.614 – 1.43)x10^6 J = 4.21x10^6 J.

The speed of the truck is calculated using
E_k = 4.21x10^6 = ½mv^2
v = √(4.187x10^6 /7275) = 24.0 m s^{-1} .

Marking Details

1 mark E_p at 10m.

1 mark E_k (remaining).

0.5 marks units.

0.5 marks magnitude.

Use of motion equations (SUVAT) = 0 marks.

d) When the truck has stopped all the kinetic energy has been converted into potential energy.
Thus, $E_p = 5.64\text{x}10^6 = mgh$
$h = 5.64\text{x}10^6 /(14550 \text{ x } 9.81)$
= 39.4 m.

Marking Details

0.5 marks Rearranged formula/working.

0.5 marks units.

1 mark magnitude.

Use of motion equations (SUVAT) = 0 marks.

e)

i. Being 25.5 m above the highway gives the truck:
$E_p = mgh = 14600 \text{ x } 9.81 \text{ x } 25.5 = 3.65\text{x}10^6$ J.
Work done by friction = $5.64\text{x}10^6 – 3.65\text{x}10^6$
= $1.99\text{x}10^6$ J.

Marking Details

1 mark calculate E_p at 25.5m.

1 mark calculate work done by friction.

ii. Thus the length of the safety ramp used by the truck (“x” in the diagram) = 25.5/sin(15) = 98.5 m.

Marking Details

1 mark correct trigonometry ratio.

1 mark correct height.

iii. W = Fs, then F = W/s = $1.99\text{x}10^6$ / 25.5
= $2.0\text{x}10^4$ N.

Marking Details

0.5 marks deducted no/wrong units.

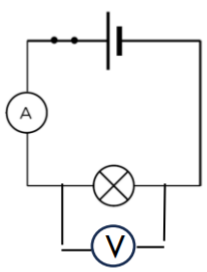
General Comments

Most students did well on this question, even though c) was challenging.

Communication of thought processes needs to be developed in many students; examiners cannot give credit for ideas they cannot reasonably follow.

Question 12

a)



Marking Details

0.5 marks deducted for each error.

b) Chemical potential energy in the cell is converted to electrical energy in the wires of the circuit, and to heat and light in the light bulb.

Marking Details

1 mark requires **two (2)** energy changes.

c) $R_T = R_1 x R_2/(R_1+R_2) = 8/6 = 4/3$

$= 1.33\ \Omega$.

Marking Details

0.5 marks deducted for no/wrong units.

d) I = V/R = 12/4

= 3 A.

Marking Details

0.5 marks deducted for no/wrong units.

e) $R_T = 6\Omega$.

Current flowing through circuit $I = V/R_T = 12/6$

= 2 A.

Voltage drop across the 4Ω bulb = IR = 2 x 4

= 8 V.

Marking Details

1 mark R_T.

1 mark current flowing through circuit.

1 mark voltage across the 4Ω bulb.

General Comments

Most candidates answered this question well.

A common error was that a **closed** switch was confused with an "off" switch, with many student answers referring to 'no current would flow'. Students are encouraged to familiarise themselves with the scientific terminology of circuits.

Teachers and students are directed to know and use the standard circuit symbols that are outlined in the course document.

Question 13

a) $P = V^2 /R$

$R = 122 /9 = 16\ \Omega$.

Marking Details

0.5 marks deducted for no/wrong units.

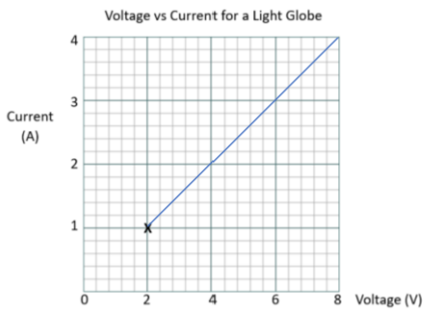
b) Energy used = 9 x 7 x 24/1000 = 1.51 kWh.

Cost = 28 x 1.51 = 42 cents (nearest cent).

Marking Details

0.5 marks for working.

c)



Marking Details

1 mark.

d) R = 1/slope, or R = V/I

= 2 Ω.

Marking Details

0.5 marks deducted for no/wrong units.

e) It is a valid point because without a potential difference (voltage), no current will flow.

Marking Details

1 mark.

General Comments

Many students found this question accessible. However, students continue to find electricity cost problems difficult, and are encouraged to use a two-step approach, first finding energy used then multiplying by the cost per unit (as shown above).

Teachers need to ensure that students are familiar with current-voltage graphs, with either voltage or current on the y-axis and the difference between them. Rulers are strongly encouraged to be used in TCE Physical Science tests and exams. Marks were deducted for lines that were not linear (notes of “this should be straight” for lines that clearly weren’t, were **not** accepted).

In general, Part e) was poorly done with many students using a mathematical approach (incorrectly) instead of scientific reasoning.

Question 14

a) 220 Amps for 1 hour = 220 amps for 3600 s.

Q = It = 220 x 3600

= 7.92×10^5 C.

Marking Details

0.5 marks for working/formula.

b) P = IV so I = P/V = 250/12.5

= 20 A.

Marking Details

0.5 marks deducted for no/wrong units.

c) R = V/I = 12/6

= 2 Ω.

Marking Details
0.5 marks deducted for no/wrong units.

d) E = Pt = IVt = 220 x 12 x 1

= 2640 Wh = 2.6 kWh.

Marking Details
0.5 marks for working/formula.

e) Connecting the devices in parallel will result in each device operating at 12 V.

The total current in the circuit will be 8 + 6= 14 A. However, current will split between each branch in the parallel circuit.

Increasing the current being drawn from the battery will decrease the time the devices can be used (decrease the time taken for the battery to “go flat” or be discharged).

Marking Details
The below marks correspond to the above statements.

0.5 marks

0.5 marks

1 mark

General Comments

Many students found question 14 part a) challenging. General guidance to students includes using past TASC exam papers in the preparation for their future exams as this type of question has been previously asked.

Parts b) and c) were well done.

Part d caused confusion for many; again clear communication would enhance students understanding and performance.

Part e) demonstrated that students need to read questions carefully to ensure their answers address what is being asked. Answers provided for this question were often hard to follow and showed that many students need to develop their understanding of the scientific theory of electricity and the relationship between voltage, current, resistance and power. This is particularly relevant for students aiming for higher grades and planning on studying Physics Level 4 in Year 12.

Section D – Criterion 7

Question 15

Name	Formula
Nitrogen gas	N_2
Oxygen dichloride	OCl_2
Copper(II) oxide	CuO
Iron(III) sulfide	Fe_2S_3
Silver phosphate	Ag_3PO_4
Zinc sulfate	$ZnSO_4$
Propyne	C_3H_4
Decane	$C_{10}H_{22}$

Marking Details

Monooxygen dichloride was accepted.

0.5 marks were deducted if Iron sulfide was stated [without Iron(III)].

Structural and condensed formulae were accepted.

General Comments

This straightforward question was generally well done. Some students however, missed the “di” in Oxygen dichloride and used “dectane” rather than decane. Some students appear to have been confused by the term “nitrogen gas” resulting in N_3 or NO_3, etc.

Question 16

a) B, D, E.

Marking Details

0.5 marks deducted for each error or omission.

0.5 marks deducted once only for using symbols of actual elements rather than A-F as requested.

b) B, C, F.

Marking Details

0.5 marks deducted for each error or omission.

c) A, E.

Marking Details

0.5 marks deducted for each error or omission.

d) C_2D

Marking Details

Li_2S was also accepted for a full mark.

e)

Marking Details

Either electron-dot or Lewis diagrams were accepted.

f) Either D^{2-} OR 2-

with electron configuration 2, 8, 8.

Marking Details

0.5 for giving the charge on the ion.

0.5 for electron configuration.

General Comments

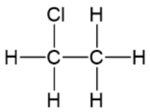
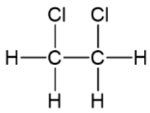
This question was mostly well done, but some students had wasted time working out the names of the actual elements in the table and then using them in their responses to sections a) to f).

A variety of strange diagrams were drawn and accepted* in 16e)due to the confusion between electron dot diagrams and Lewis diagrams.

*provided they showed sharing of electrons and correct orientation of the atoms.

Question 17

a)

	Ethane	Ethene
Name the reaction (if any)	Substitution	Addition
Name the product(s) formed. (2 mks)	(1-)chloroethane and hydrogen chloride (**not** hydrochloric acid) (½ mark each)	1,2-dichloroethane (1 mark)
Draw the structure of the organic product(s). (2 mks)	1 mark 	1 mark 

Marking Details

0.5 marks each.

b) $C_4H_8(g) + 6O_2(g) \rightarrow 4CO_2(g) + 4H_2O(g)$.

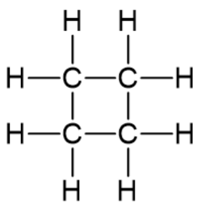
Marking Details

1 mark deducted if equation not balanced.

0.5 marks deducted for no/incorrect states.

0.5 marks deducted for each incorrect formula.

c) Cyclobutene



Marking Details

0.5 marks given for 1-methylcyclopropane, if correctly drawn and named.

d) Butane is a non-polar molecule. Hence, there are weak intermolecular forces (dispersion forces) between molecules. These are easily overcome and thus the substance boils at a relatively low temperature.

Calcium oxide is ionic. The anions and cations are held on the 3D lattice by strong electrostatic forces of attraction. These require a large amount of energy to overcome, and hence the boiling point of CaO is high.

Marking Details

For each compound:

- 0.5 marks for stating structure.
- mark for describing strength and type of forces holding particles together.
- 0.5 marks for relating this to the separation and energy involved in boiling.

General Comments

a) This question was poorly answered with many students responding that the Ethane will not react at all.
b) This section was reasonably well done but many students lost marks for including H_2O as a liquid product (not feasible in a combustion reaction).
c) Some students named the isomer as ‘cyclic butane’ rather than ‘cyclobutane’.
d) This section was poorly done with a number of students stating that CaO is a network covalent compound, or that it has ‘weak intra-molecular covalent bonds, etc. Others recognised CaO as an ionic compound but still referenced intermolecular forces. The majority of students failed to clearly link the boiling points to features of the compounds’ bonding.

Question 18

a) Sodium is a metal and hence is composed of a 3D lattice of cations surrounded by delocalised and mobile valence electrons.

Marking Details

0.5 marks each for descriptions of:

- Lattice, cations, mobile and valence electrons.

b) Freely moving (mobile) Na+ and Cl- ions.

Marking Details

0.5 marks for stating ‘ions’.

0.5 marks for recognising mobility.

c) Group I elements are metals. They react by losing valence electrons.

Moving down the group the valence shell is increasingly distant from the nucleus, which means the electrostatic attraction between the nucleus and valence electron decreases down the group. This makes it easier for the element to lose its valence electron, and hence reactivity increases down the group.

Group VII elements are non-metals. They react by gaining or sharing a valence electron.

Moving down the group the valence shell is further and further from the nucleus, decreasing the extent of the attraction of the nucleus to the valence shell, or an additional electron. Thus, these elements become less reactive moving down the group.

Marking Details

1 mark each.

General Comments

a) A common misinterpretation of the question led students to describe the structure of a sodium atom rather than the metal. Others included anything they knew about metals, describing lustre, malleability, etc., but earning no marks. A small number described a metallic lattice with cations surrounded by a sea of delocalised electrons. This response earned full marks.

b) A common error was “delocalised electrons”.

c) Few students were able to clearly describe decreased forces of electrostatic attraction that result from increased shielding as electron shells are added and increased forces of electrostatic attraction as a result of additional nuclear charge (more protons). Those who could found it easier to explain the trends in reactivity.

Question 19

a) $Ca(NO_3)_2(aq) + Na_2CO_3(aq) \rightarrow CaCO_3(s) + 2NaNO_3(aq)$.

Marking Details

0.5 marks deducted for each error.

b) $Ca^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CaCO_3(s)$.

Marking Details

0.5 marks deducted for each error, including states.

Full ionic equations earned 0 marks.

c) NO_3^- (or nitrate) and Na^+ (or sodium ions).

Marking Details

0.5 marks each.

Words or symbols accepted.

General Comments

This question was reasonably well done.

a) Some students did not recognise the “including states” section of the question.

b) Some students missed charges in ionic equations. Inclusion of valency numbers tended to confuse students.

Question 20

a) C: sodium sulfate

D: barium nitrate

E: silver nitrate

Marking Details

1 mark each.

b) Flame test.

Marking Details

Other answers gained no marks.

General Comments

Many students did not attempt this question.

a) Some students wrote the same compound in each space, presumably to get 1 out of 3 marks when they did not know how to solve the problem.

b) Most who answered this question did so correctly, but every other test covered in the course was mentioned as well as some that are not condoned.

Section E – Criterion 8

In this section, students are reminded that when tackling a "show that" question, it is essential to use their calculated answer rather than the approximate answer provided in the question. This approach ensures precision in subsequent calculations. Additionally, the consistent use of SI units, correct molar masses being used in calculations (as these are provided in the formula sheet), and accurate unit conversions is crucial.

Care should be taken to avoid including coefficients from chemical equations in molar calculations, as this was a common error. Finally, carefully reading the question to understand its context and addressing the specific requirements are key skills that students should continue to develop.

Question 21

a) 2 x 1.008 + 32.06 + 4 x 16.00

= 98.08 $gmol^{-1}$.

Marking Details

0.5 marks for correct working, but incorrect final solution.

b) n = m/M = 4.6/98.08

= 0.0469 mol.

Marking Details

0.5 marks for correct working, but incorrect final solution.

c) #H atoms = 2 x n x N_A = 2 x 0.0469 x 6.02 x 10^{23}

= 5.65 x 10^{22} H atoms.

Marking Details

0.5 marks for x 2 H atoms.

0.5 marks for x N_A.

d) c = n/V = 0.0469/0.250

= 0.188 $molL^{-1}$.

Marking Details

0.5 marks for correct working but incorrect final solution.

e) pH is a measure of H+ ion concentration.

Sulfuric acid is diprotic whereas nitric is monoprotic so sulfuric acid gives more H+ ions to solution.

Solution of sulfuric acid will therefore have a lower pH.

Marking Details
1 mark each.

General Comments

Question 21 parts a – d were generally well answered by most students. Most of the errors in these questions came from calculation errors. 21c) caused some issues, with many students not knowing how to go from the number of molecules to number of atoms, often dividing by 7 to find the total number of atoms.

21e) was a challenging question for students, with a variety of answers. Many students did not understand the difference between strength and concentration, and it was clear students did not understand what pH was measuring. The best responses clearly mentioned the monoprotic and diprotic nature of the two acids, but simply identifying that sulfuric acid donated 2:1 H^+ ions was accepted. Students should be aware of the nature of acids and comparing two strong acids in relation to the pH scale.

Question 22

a)

	Mg : C : O
Mass (percent)	28.8 : 14.2 : 57.0
Convert to mole	$\frac{28.8}{24.3} : \frac{14.2}{12.01} : \frac{57.0}{16.0}$
	1.2 : 1.2 : 3.6
Dividing by smallest ratio	$\frac{1.2}{1.2} : \frac{1.2}{1.2} : \frac{3.6}{1.2}$
	1 : 1 : 3

Therefore, the empirical formula is $MgCO_3$.

Marking Details
1 mark for converting to Mole

1 mark for dividing by smallest ratio

b) $MgCO_{3(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$.

Marking Details
1 mark for products and reactants.

0.5 marks for correct balancing.

0.5 marks for correct states.

1 mark deducted for H_2CO_3 (no CO_2 or H_2O).

c) The pH will increase towards a maximum of 7 / as the acid is neutralised.

Marking Details
1 mark each.

d) $Mg_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$.

Marking Details
0.5 marks for products and reactants.

0.5 marks for correct balancing.

General Comments

Question 22 was well answered by most students. In part a), some students incorrectly divided the molar mass by the given values, causing issues with their ratios. It was expected to see mole calculations and simplifying due to the fact the correct empirical formula was given in the question.

Part b) saw many students forgetting to include, or including incorrect, states, even though it was asked for clearly in the question. Some students also incorrectly listed H_2CO_3 as a product. Students should be using their formula sheet to guide them to the correct products for the acid-base reactions. Students were penalised for indicating charges in the reaction.

Part c) saw many students achieve partial marks for noting an increase, but were unable to indicate that the solution would reach pH 7 or become neutral. A common misconception was that if something is becoming less acidic, it is becoming basic. A question that asks about the pH scale should clearly refer to the scale in provided answers.

Part d) was generally well answered, although students were frequently penalised for diatomic metals.

Question 23

a) It is a proton (or hydrogen ion (H^+)) donor.

Marking Details
1 mark.

b) HF / hydrogen fluoride.

Marking Details
1 mark.

c)

i. n = m/M = 50.00/20.008
= 2.50 mol.

Marking Details
0.5 for working but incorrect solution.

ii. Mole ratio is 1:2, 2.50/2

= 1.25 mol of $C_2H_{10}N_2^{2+}$ formed.

Marking Details
0.5 marks deducted for multiplying by 2.

iii. m = n x M= 1.25 x 62.12
= 77.65 g.

Marking Details

0.5 marks for correct molar mass.

0.5 for solution.

General Comments

Question 23 was well answered by most students. However, students frequently noted electron movement rather than protons / H^+ ions. Students should revise their definitions for Bronsted-Lowry acids and bases to be aware of the movement of protons / H+ ions.

Mole ratios were also a challenge for some, with lots of students incorrectly multiplying rather than dividing the moles by two (2) in 23 c) ii. In the same question the incorrect molar mass was too often used, as many students did not notice that two (2) less Hydrogen atoms were present within the ion formed.

Question 24

a) A weak acid only partially ionises (does not fully dissociate) to form H^+ ions,

e.g. $CH_3COOH_{(aq)} \rightleftharpoons CH_3COO^-_{(aq)} + H^+_{(aq)}$.

Marking Details

1 mark for statement.

1 mark for equation (equilibrium arrow not required).

b) 14.50 – 0.20 = 14.30 ml.

Marking Details

0.5 marks deducted if not 2 decimal places (14.3 ml).

c) (14.50 + 14.40 + 14.30) / 3

= 14.40 mL.

Marking Details

1 mark for correct answer.

No marks were awarded for including rough titre value.

d) n = cV = 0.1234 x 0.0144

= 1.777×10^{-3} mol.

Marking Details

0.5 marks deducted if millilitres not converted to litres.

e) n(NaOH) = 1.777×10^{-3} mol

n (citric acid in each titration) = 1/3 x n(NaOH)

= 5.923×10^{-4} mol.

c (citric acid in diluted juice) = n/V = 5.923×10^{-4} /0.025

= 0.02369 $molL^{-1}$.

Marking Details

1 mark for correct ratio.

1 mark for finding the concentration.

f) c (citric acid in undiluted juice) = 0.02369 x 10

= 0.2369 $molL^{-1}$.

concentration in g L^{-1} = concentration (mol L^{-1}) x M_r

= 0.2369 x 192.1

= 45.51 g L^{-1}. (4 sig figs).

Marking Details

1 mark for x 10.

1 mark for x 192.1.

General Comments

Question 24 caused many issues for students, both within the more difficult sections and the more standard titration questions.

24a) was poorly answered. Many students incorrectly noted the movement of hydrogen ***atoms*** rather than hydrogen **ions**, as well as a variety of incorrect answers. Credit was not awarded for this. Students found the jump from citric acid to ethanoic acid challenging.

24b) saw students missing easy marks for significant figures, with plenty of evidence in the table for 4 significant figures. It was clear that some students found the table difficult to read and interpret.

24c) was poorly done, with many students failing to calculate the average or using incorrect values. Students should be aware that anomalous results should not be included when mean averages are calculated.

24d) and e) were also poorly done. Students did not correctly interpret the information provided, often using the wrong volume or failing to convert the volumes given in ml to L. It is important for students to use their time effectively to plan their approach to such questions, ensuring they have identified the correct values to be used. Students **should not** be using $c_1v_1 = c_2v_2$ for titration questions, and it is advised that teachers do not teach this formula to students as it invariably hampers their understanding of the titration theory.

24f) was a challenging question for most students who attempted it, though many did not. Those who did attempt this question often struggled with the required calculations, and did not understand that the dilution needed to be considered. Students should be careful to consider multiple stage questions and be aware of previously provided or calculated information. Given the complexity of the question, marks were not deducted for incorrect significant figures in this question.

Question 25

a. $2Na_{(s)} + 2H_2O_{(l)} \rightarrow 2NaOH_{(aq)} + H_{2(g)}$.

Marking Details

0.5 marks for products and reactants.

0.5 marks for correct balancing.

b. n(Na) = m/M = 6.5/22.99

= 0.283 mol

$n(H_2)$ = ½ x n(Na)

= 0.141 mol

$m(H_2)$ = n x M = 0.141 x 2.016

= 0.284 = 0.28 g (2 significant figures).

Marking Details

1 mark for finding n(Na).

1 mark for correct ratio.

0.5 marks for x 2.016.

0.5 marks for two (2) significant figures.

c. c = n/V = 0.29/1.00

= 0.28 $molL^{-1}$.

Marking Details

0.5 marks deducted if no/wrong units.

d. n (H_2O reacting) = n(Na) = 0.28.

m (H_2O reacting) = n x M = 0.28 x 18.016 = 5.10 g.

V (H_2O reacting) = 5.10 mL (density is $1.0gml^{-1}$).

Hence the volume of water remaining in the beaker, in which the NaOH is dissolved, is 1000-5.10 = 994.9 mL, or 0.995 L.

When the concentration of NaOH is calculated using this value: c (NaOH) = n/V = 0.283/0.995

= 0.284 mol L^{-1}.

This is 0.28 $molL^{-1}$to 2 significant figures, thus in this case the teacher is justified.

Marking Details

1 mark for finding the mass/volume of water.

1 mark for further supporting calculations.

1 mark for written supporting statement.

Other approaches concluding that the mass/percentage/moles of water reacted relative to the mass/percentage/moles of water present was negligible are acceptable, if communication of ideas is clear and supported with calculations.

General Comments

Question 25 parts a – c were relatively well answered, with most students achieving some marks for these parts. Students should be aware that hydrogen gas is diatomic and, once again, metals are not diatomic.

For part b), students who recognised it as a reacting quantities question were able to answer it well. Marks were deducted for incorrect significant figures. Students should ensure they identify their reaction ratio when providing a solution.

Part c) caused issues for some students due to the wording ‘ignoring the water’, meaning many students incorrectly thought they could not use the provided volume.

Part d) was left unattempted by many students, which may have been a timing issue. Those that did attempt this question found it challenging with very few gaining full marks.