**Atomic/Molecule Structure A-Level Worksheet Answers**

**Hydrogen Spectra and Related**

**1. 2014. Unit 1. Qn 8.**

**b).** i) 3 energy levels between n=2 and n=∞ becoming closer together.

First gap must be less than that between n=1 and n=2.

ii) Any arrow pointing upwards from n=1 to n=∞.

**c).** i) Visible.

ii) (Not correct because) Balmer series corresponds to energy transitions involving n=2.

For ionisation energy need Lyman series / energy transitions involving n=1.

**2. 2015. Unit 1. Qn 6c.**

Lines are formed from electron being excited and jumping to a higher energy level.

Falling back down to the n=2 level.

Emitting energy / photon of light.

Lines become closer since the electron energy levels of a hydrogen atom become closer.

QWC mark.

**3. 2016. Unit 1 (old unit). Qn 7d.**

ii) Electrons are excited and absorb energy as they move to a higher energy level.

When they relax / return to a lower level.

This energy is given out as energy in the visible part of the (electromagnetic) spectrum.

**4. 2016. Unit 1. Qn 12c.**

As the group is descended the bond energies decrease and the wavelengths increase / astatine is below iodine in the Periodic Table / maximum wavelength would be greater than 400 nm.

Coloured gas linked with the visible region.

**5. 2017. Unit 1. Qn 6a.**

i) Energy = 3.03 x 10-19 J

ii) Measuring the convergent frequency / wavelength at the convergence limit

Calculate the ionisation energy using ΔE = hf

**6. 2018. Unit 1. Qn 8.**

**a).** i) Furthest line to the left.

ii) Electron falls from higher energy levels to lower energy levels

The difference between any two energy levels is fixed / energy levels are quantised.

**b).** ii) f = 3.29 x 1015

**7. 2019. Unit 1. Qn 10.**

**a).** Electron promoted to a higher energy level.

Falls back down to a lower energy level.

**b).** i) Each series corresponds to electrons falling to different energy levels.

ii) Energy difference between the shells decreases / energy levels get closer together.

**c).** i) Ionisation of the atom / point at which electron leaves the atom.

ii) 1312 kJ mol-1

**8. 2014. Unit 4. Qn 4b.**

ii) The colour will be black as the compound absorbs blue

**9. 2015. Unit 4. Qn 1a.**

blue, higher, higher

**10. 2017. Unit 4. Qn 9a.**

ii) It does not absorb in the visible region.

**11. 2017. Unit 4. Qn 10a.**

ii) The wavelength of the light absorbed increases as the pH increases; in the visible spectrum, violet has the shortest wavelength and this increase as the colour moves towards red.

iii) f = 7.79 x 1014

iv) 311

**12. 2018. Unit 3. Qn 9d.**

i) E = 231

**13. 2019. Unit 4. Qn 10a.**

iii) f 7.32 x 1014 Hz

**Electron Configurations and Ionisation Energies**

**14. 2014. Unit 1. Qn 1.**

1s22s22p63s23p6

**15. 2014. Unit 1. Qn 8d.**

i) Q(g) → Q(g)+ + e-

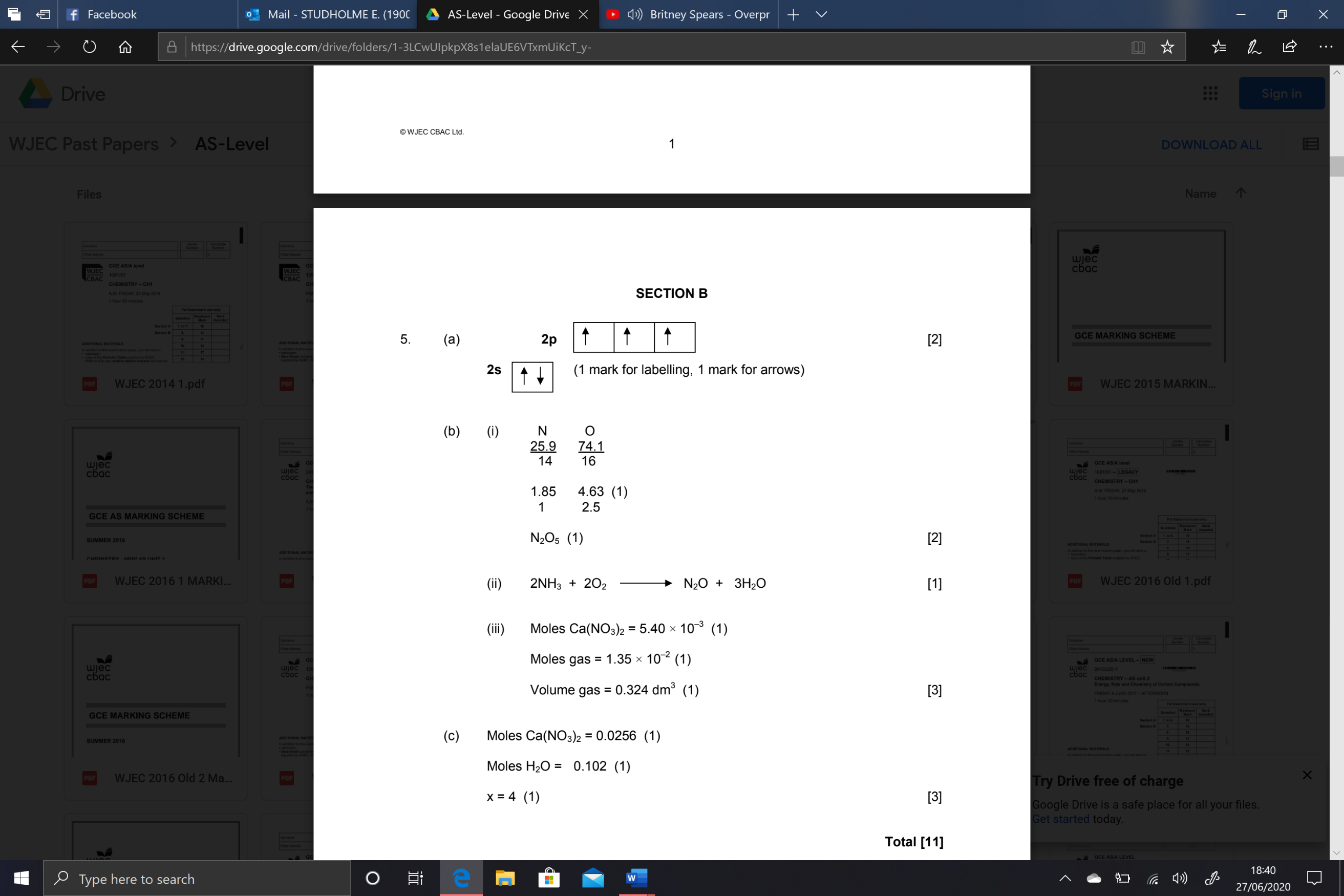
ii) Group 6

iii) In T there is more shielding.

The outer electron is further from the nucleus.

The increase in shielding outweighs the increase in nuclear charge / there is less effective nuclear charge.

QWC mark.

**16. 2015. Unit 1. Qn 5a.**

**17. 2015. Unit 1. Qn 6.**

**a).** i) Energy required to remove one mole of electrons from one mole of atoms / to form one mole of positive ions from one mole of atoms in the gaseous state (to form one mole of gaseous ions).

(Accept correct equation).

ii) Cross between Na and Mg crosses.

iii) P only has unpaired electrons, S has a pair of electrons in the 3p orbital.

Repulsion between the paired electrons make it easier to remove one of the electrons.

**b).** i) Effective nuclear charge is greater / electron being removed from a positive ion.

ii) Accept from 6000 – 9000.

**18. REMOVED**

**19. 2015. Unit 2. Qn 1.**

(1s2)2s22p6

**20. 2015. Unit 2. Qn 9a.**

ii) 1st ionisation energy decreases as group is descended / as element has higher Ar.

(Atom) becomes larger / outer electron further from the nucleus / more shielding / less effective nuclear charge.

iii) As group descended outer electron more easily lost.

**21. 2015. Unit 2. Qn 10a.**

The last / valence electron entered a p orbital/sub-shell.

**22. 2016. Unit 1. Qn 1.**

3d 4s 4p

**↿⇂**

**↿**

**↿**

**↿**

**↿⇂**

**↿⇂**

**↿⇂**

**↿⇂**

**↿⇂**

**23. 2016. Unit 1 (old unit). Qn 1.**

3s 3p 3d 4s

**↿⇂**

**↿⇂**

**↿**

**↿**

**↿**

**↿**

**↿**

**↿⇂**

**↿⇂**

**↿**

**24. 2016. Unit 1 (old unit). Qn 2.**

**B**

**25. 2016. Unit 1 (old unit). Qn 10a.**

1s22s22p63s2

As successive electrons are removed the value of the ionisation energy increases due to electrons being removed from an increasingly positive charged ion / greater effective nuclear charge.

The large increase in value between 2 and 3 is due to removal of an electron from the 2p subshell which is closer to the nucleus.

There is also a large difference in the figures between 10 and 11 where an electron is being removed from the 1s energy level, which is closest to the nucleus.

Credit correct reference to changes in “shielding” for

Any four of five points.

QWC mark.

**27. 2016. Unit 2 (old unit). Qn 4a.**

Sodium, Aluminium, Magnesium, Silicon, Chlorine

**27. 2017. Unit 1. Qn 6b.**

i) Hydrogen lower value since it has a smaller nuclear charge.

Electron comes from the same shell / no extra shielding.

ii) Any two of the following:

**.** Hydrogen higher value since no shielding of outer electron / lithium has shielding of outer electron.

**.** Outweighs smaller nuclear charge / greater effective nuclear charge.

**.** H outer electron closer to the nucleus / lithium loses electron from higher energy sub-shell.

**28. 2018. Unit 1. Qn 2.**

Group 2.

**29. 2018. Unit 1. Qn 3.**

3s 3p 3d 4s

**↿⇂**

**↿⇂**

**↿⇂**

**↿**

**↿**

**↿**

**↿**

**↿**

**↿**

**↿⇂**

Ne

**30. 2018. Unit 1. Qn 7b.**

Nitrogen is higher since it only has unpaired 2p electrons, O has two unpaired and two paired 2p electrons /

N: 1s22s22p3, O: 1s22s22p4

Repulsion between paired electrons makes it easier to remove one of the electrons / takes more energy to remove unpaired electron.

**31. 2018. Unit 1. Qn 8b.**

i) This is the energy required to remove an electron from an atom of hydrogen / for an electron to go from n=1 to n=∞ in the gaseous state.

**32. 2019. Unit 1. Qn 4.**

**↿⇂**

**↿⇂**

**↿⇂**

**↿⇂**

**↿⇂**

**33. 2019. Unit 1. Qn 9a.**

i) **C**

Contains two shells not three / less shielding of outer electron.

Of the elements with two shells it contains greatest nuclear charge / most protons.

ii) **G**

Lowest and further left on PT.

**34. 2018. Unit 3. Qn 1.**

1s22s22p63s23p63d104s1

**35. 2019. Unit 3. Qn 1.**

3d7

**Lewis Structures and VSEPR**

**36. 2014. Unit 2. Qn 6.**

**C** and **E**.

**37. 2015. Unit 2. Qn 10b.**

ii) 109° - 110°

Pairs of electrons move towards positions of minimum repulsion / of maximum separation.

**38. 2016. Unit 1. Qn 10b.**

i) Tetrahedral

**39. 2016. Unit 1. Qn 10d.**

i) (There are six bonding pairs of electrons and no lone pairs - ) position of minimum repulsion taken up.

Drawing shows clear octahedral shape.

Bond angle is 90° equatorial / equatorial or 90° equatorial / vertical (accept 180° if vertical bonds only considered).

**40. 2016. Unit 2 (old unit). Qn 9a.**

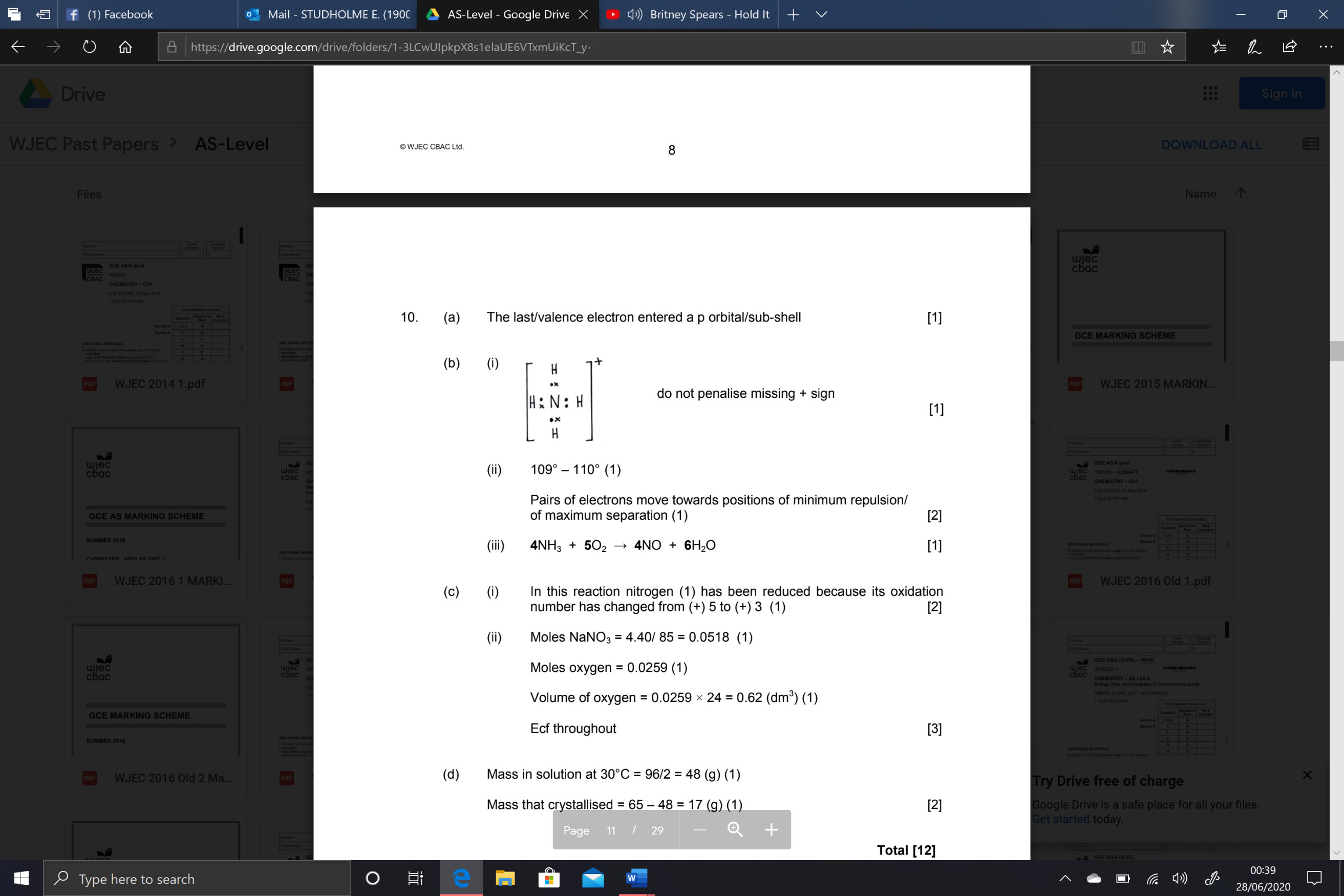
ii) 109(.5)°

iii) Trigonal pyramidal OR diagram.

Three bond pairs and one lone pair.

Electron pairs repel each other to be as far apart as possible / lone pairs repels more than the bonded pair.

**41. 2015. Unit 2. Qn 10b.**

i)

(Missing positive sign is allowed).

**42. 2017. Unit 1. Qn 6d.**

The student is incorrect because:  
**.** H2O contains two bonding pairs and two lone pairs of electrons

**.** BeH2 contains two bonding pairs only

Therefore different shapes since electron pairs arrange themselves to be as far apart as possible / different number of electron pairs.

**43. 2019. Unit 1. Qn 13c.**

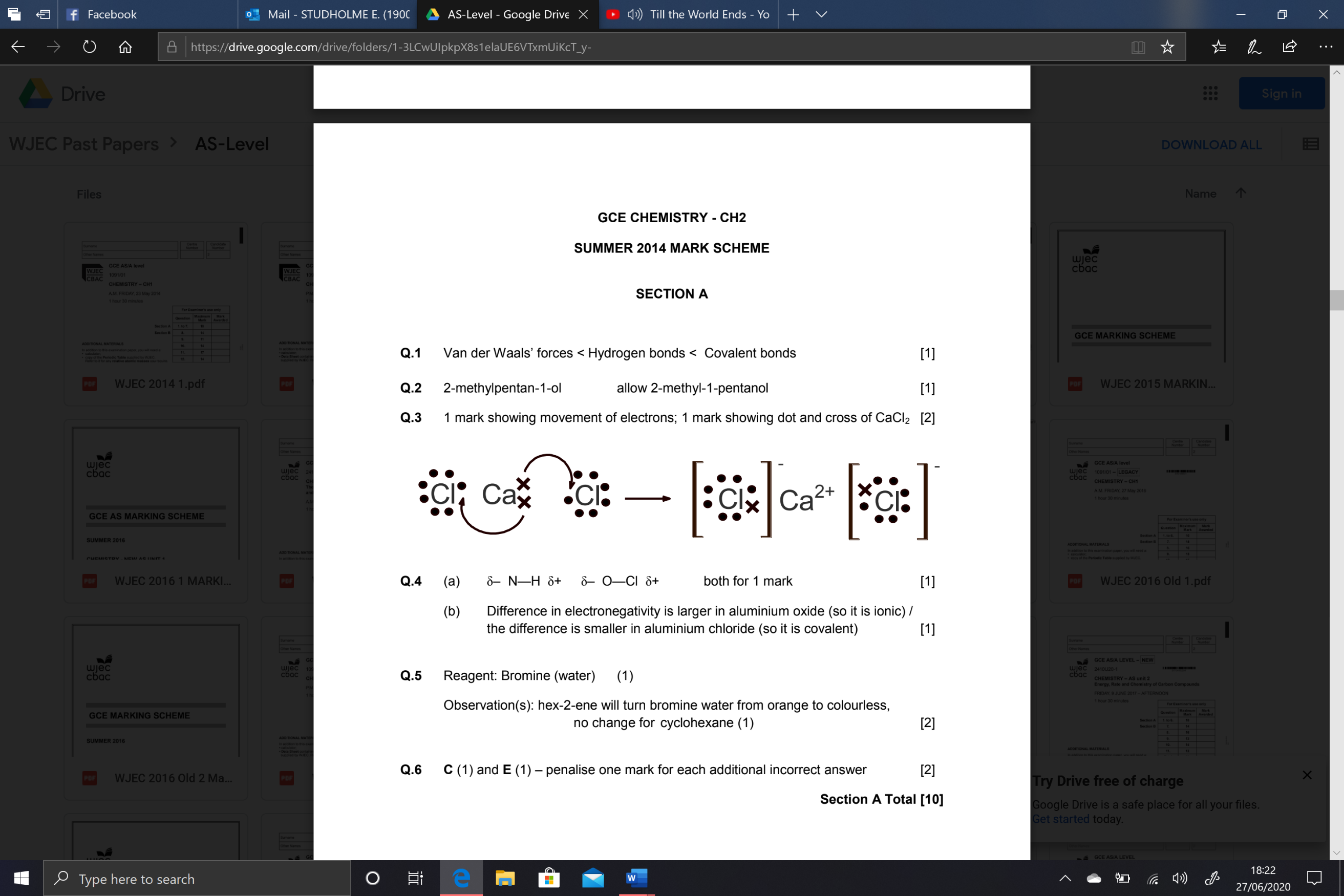
ii) Octahedral

iii) [ClF2]+ has two bond pairs and two lone pairs.

[ClF2]- has two bond pairs and three lone pairs.

Student is correct – different number of electron pairs will give rise to different shapes.

**Polarity, Electronegativity and Bonding**

**44. 2014. Unit 2. Qn 3.**

**45. 2018. Unit 1. Qn 5.**

**a).** Ability to attract electrons in a covalent bond / a shared electron pair.

**b).** Increase in number of protons / charge on the nucleus

**46. 2014. Unit 2. Qn 4.**

**a).** δ- N – H δ+ δ- O – Cl δ+

**b).** Difference in electronegativity is larger in aluminium oxide (so it is ionic) / the difference is smaller in aluminium chloride (so it is covalent).

**47. 2014. Unit 2. Qn 9e.**

Pair of shared electrons in both.

Covalent – 1 electron from each atom **and**

Co-ordinate – 2 electrons from same atom.

**48. 2017. Unit 1. Qn 3.**

**b)** e.g. Al2Cl6, NH4+

**49. 2015. Unit 2. Qn 9b.**

i) Electronegativity (difference between the atoms).

The bigger the difference the more likely is an ionic bond / ORA for covalent.

ii) Ionic: high electron density centred around ions / shown on diagram.

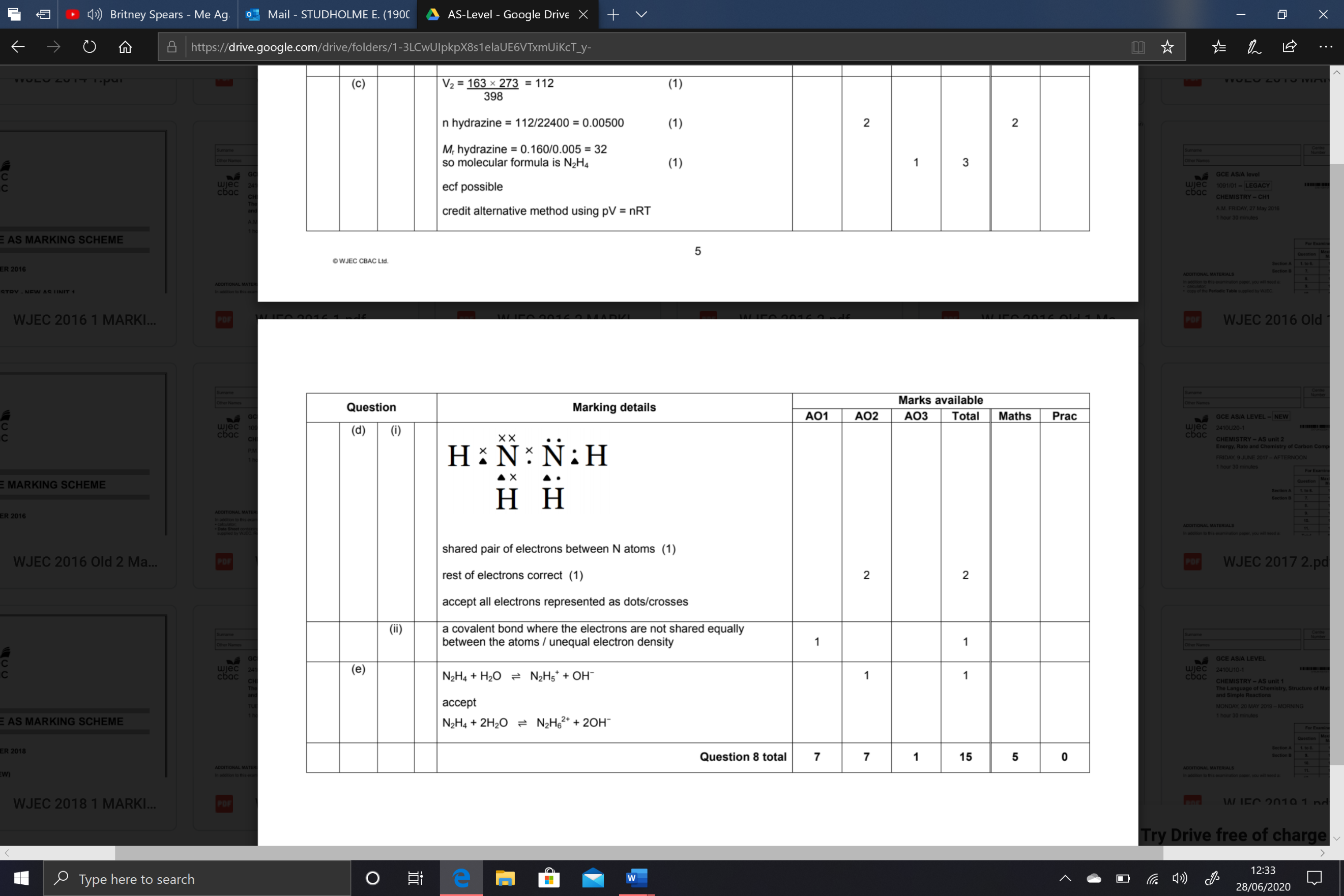
Covalent: high electron density between nuclei/atoms / shown on diagram.

Intermediate: high electron density between nuclei/atoms but higher nearer one of them / ions with electron distortion of negative ion.

**50. 2017. Unit 1. Qn 2.**

Sodium and oxygen.

They have the largest electronegativity difference.

**51. 2018. Unit 1. Qn 8d.**

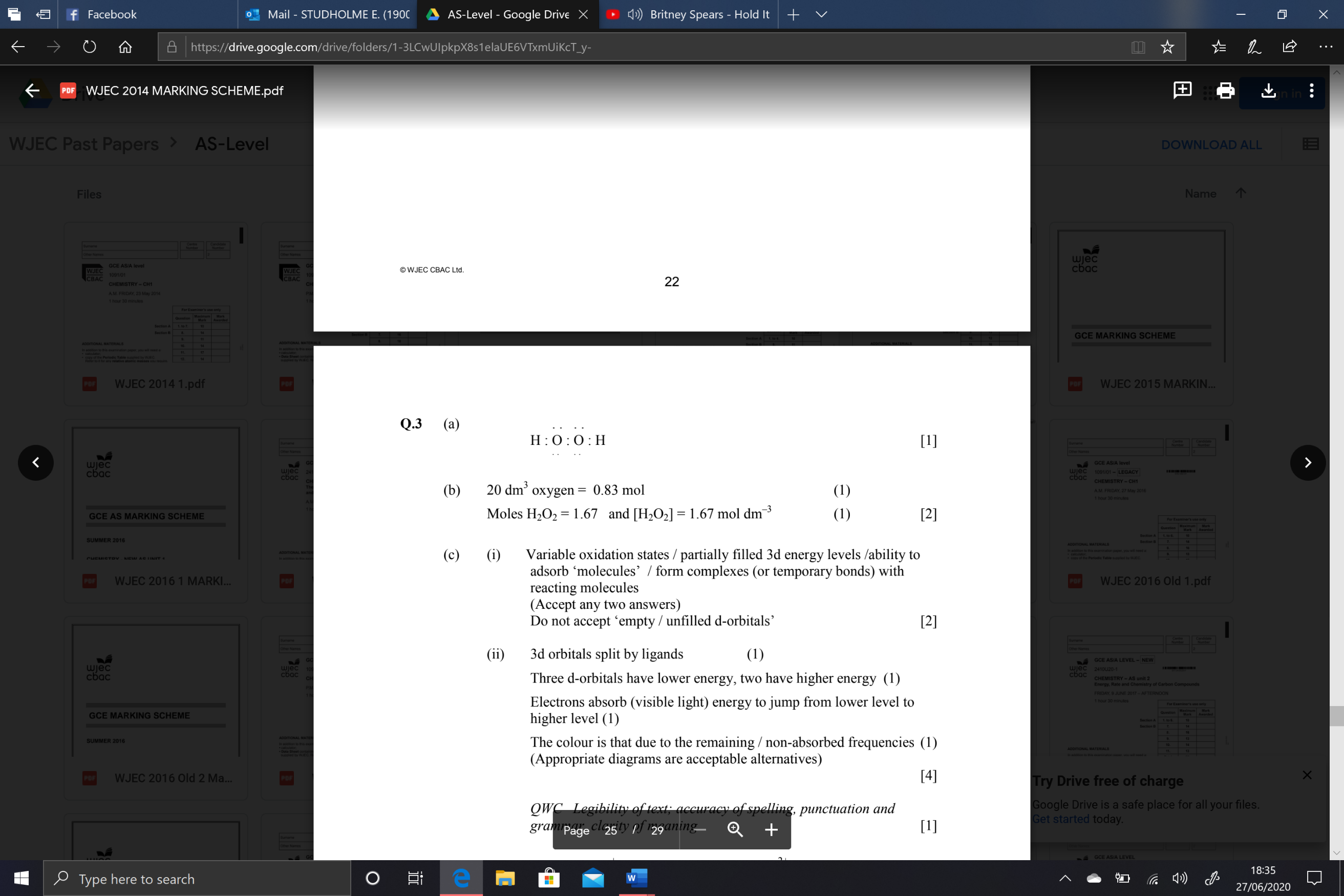
i)

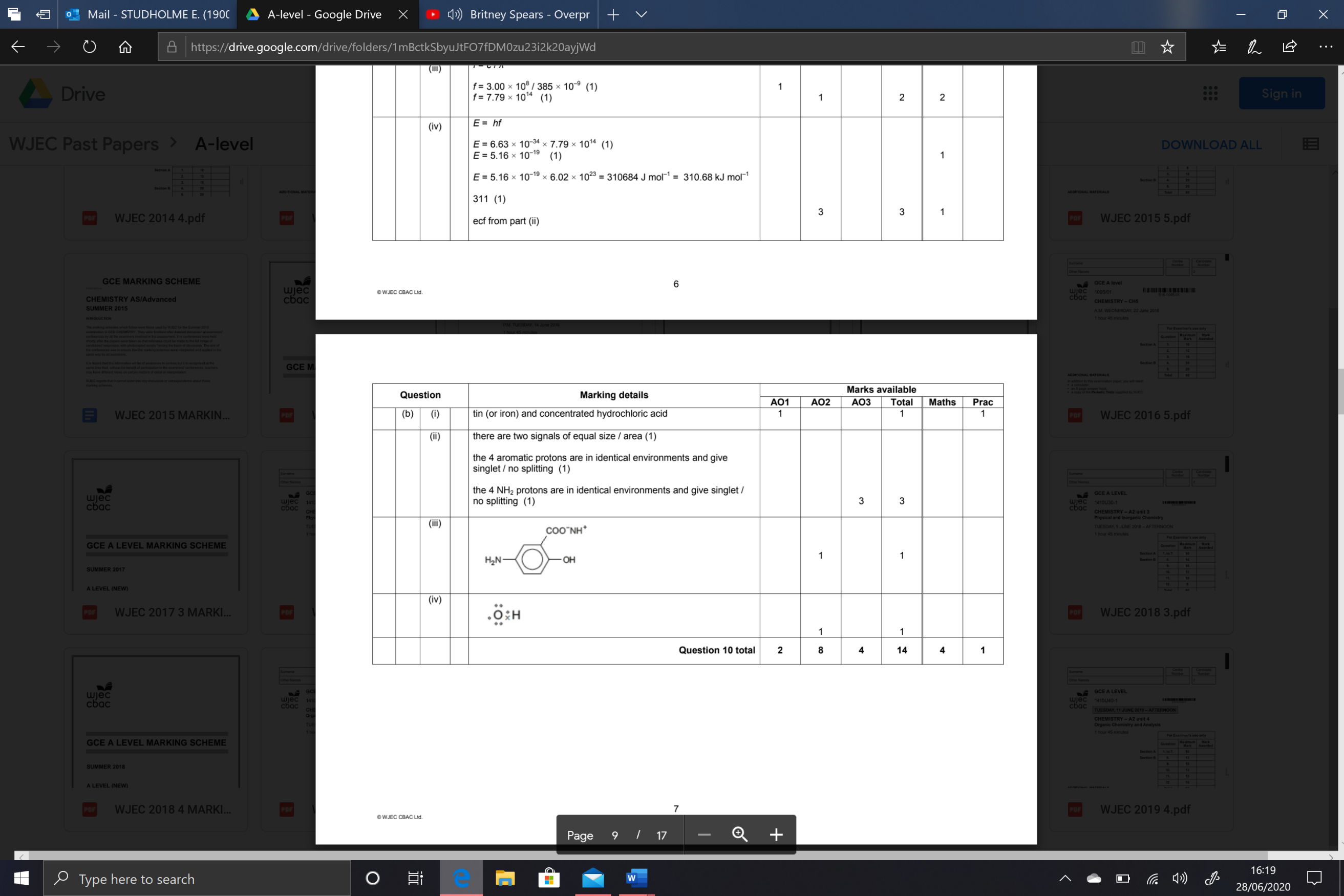
Shared pair of electrons between N atoms.

Rest of electrons correct. Accept all electrons represented as dots / crosses.

ii) A covalent bond where the electrons are not shared equally between the atoms / unequal electron density.

**52. 2014. Unit 5. Qn 3a.**



**53. 2017. Unit 4. Qn 10b.**

iv)

**Solid Structures**

**54. 2014. Unit 2. Qn 9c.**

i) 6:6

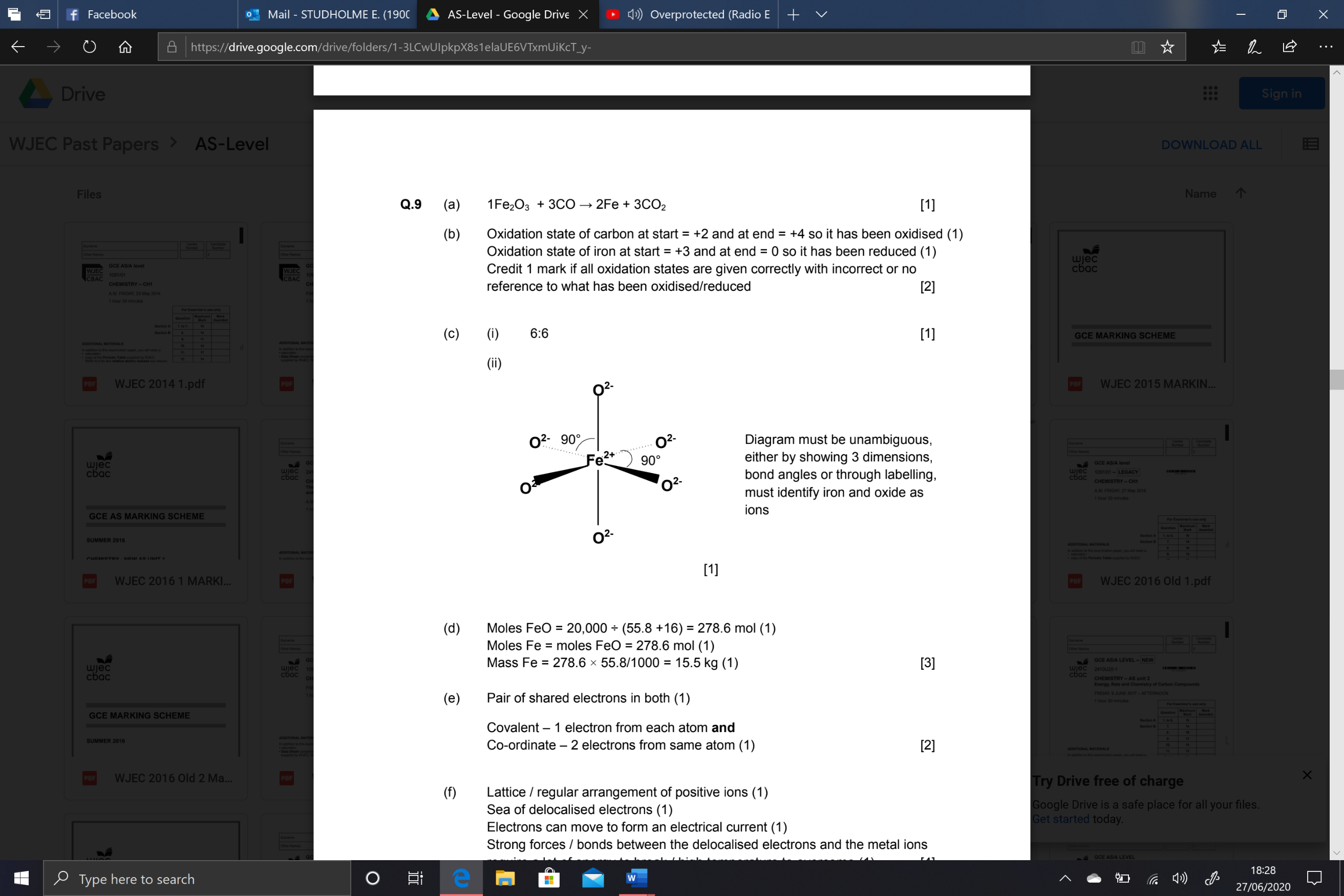
ii)

Diagram must be unambiguous, either by showing 3 dimensions, bond angles or through labelling, must identify iron and oxide ions.

**55. 2014. Unit 2. Qn 9f.**

Lattice / regular arrangement of positive ions.

Sea of delocalised electrons.

Electrons can move to form an electrical current.

Strong forces / bonds between the delocalised electrons and metal ions require a lot of energy to break / high temperature to overcome.

QWC mark.

**56. 2015. Unit 2. Qn 12a.**

Any three of the four following points:

**.** Bonding is metallic

**.** This is attraction between the sea / delocalised electrons and the positive ions

**.** Al3+ has more electrons in the sea than Na+ / Al3+ has a higher charge density than Na+

**.** More energy is needed to overcome forces in Al

QWC mark.

**57. 2016. Unit 1. Qn 8c.**

Cubic structure shows alternating different ions.

Ions labelled as Mg2+ and S2-.

**58. 2016. Unit 1. Qn 10b.**

ii) There are no free electrons or ions to carry charge

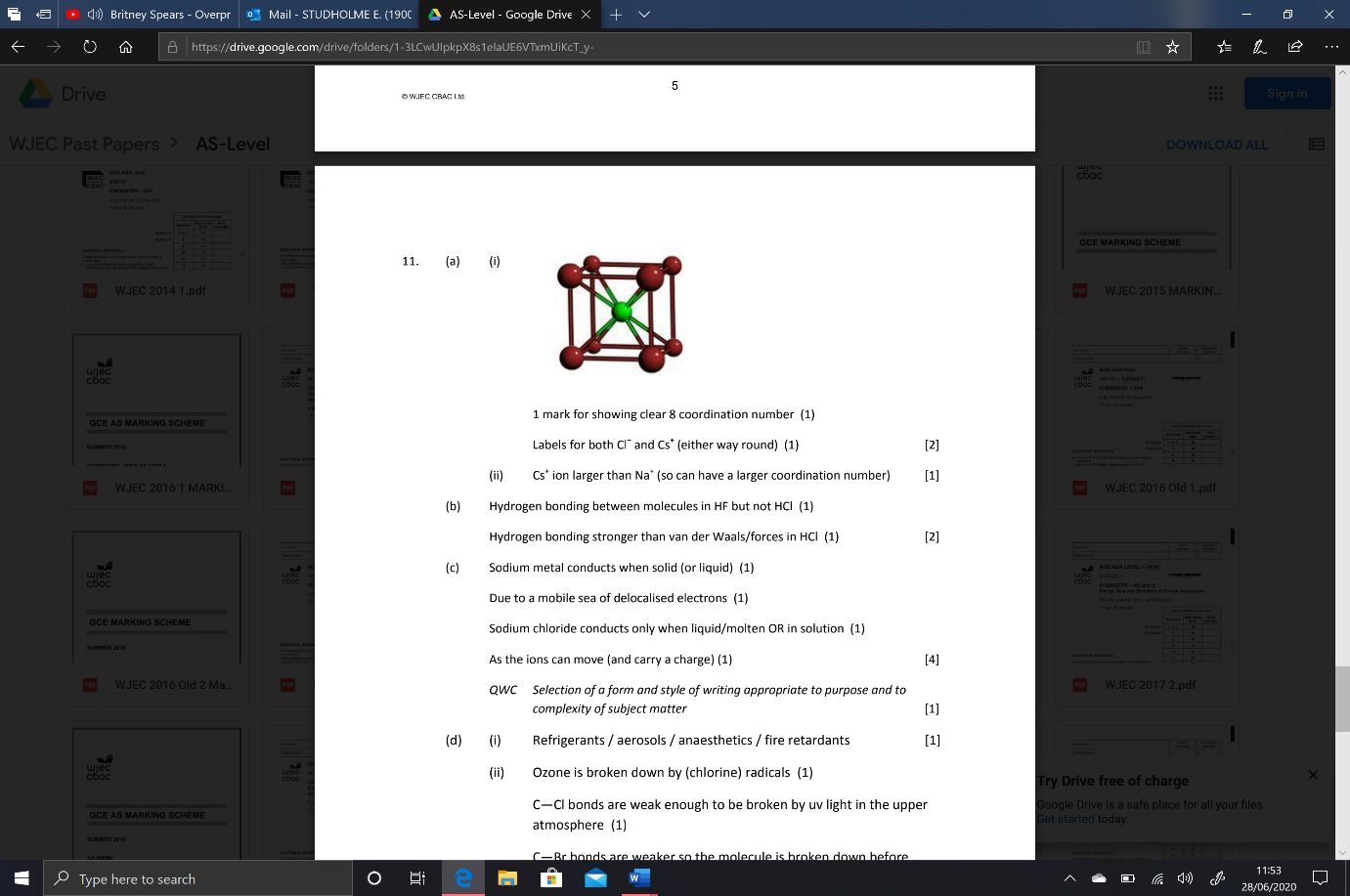
iii) Any of the following

**.** There are no electronegativity differences in the Si-Si bond

**.** All the bonding electrons are shaped equally between the four Si atoms

**.** Si cannot lose or gain four electrons

**59. 2016. Unit 2 (old unit). Qn 4b.** Chlorine, Sodium, Magnesium, Aluminium, Silicon

**60. 2016. Unit 2 (old unit). Qn 11.**

**a).** i)

Must show 8 co-ordination number

Labels for both Cs+ and Cl-

ii) Cs+ ion larger than Na+ (so can have a larger co-ordination number).

**c).** Sodium metal conducts when solid (or liquid).

Due to a mobile sea of delocalised electrons.

Sodium chloride conducts only when liquid / molten OR in solution.

As the ions can move (and carry a charge).

QWC mark.

**61. 2017. Unit 1. Qn 9e.**

i) Calcium chloride contains a lattice of oppositely charged ions (that are attracted to each other) / in the solid state the ions cannot move freely.

In the molten state / in solution the ions are free to move and carry electricity.

iii) Bonding in magnesium consists of a regular array of metal ions surrounded by a ‘sea’ of delocalised valence electrons.

When a force is applied the layers of metal ions slide over each other forming a new shape.

**62. 2018. Unit 1. Qn 7a.**

ii) Aluminium has more valence electrons than sodium therefore stronger metallic bonds.

iii) Silicon has a giant molecular structure, phosphorus only has weak forces between the molecules.

**63. 2019. Unit 1. Qn 9d.**

Bonding consists of (a regular array of) metal ions surrounded by a ‘sea’ of delocalised / valence electrons.

(Electrostatic) attraction between ions and electrons.

(When a force is applied) the layers of metal ions slide over each other forming a new shape.

Credit possible for appropriate diagrams.

**64. 2019. Unit 1. Qn 13.**

**b).** ii) Iodide ion larger than chloride ion so less attraction to sodium ion.

Less difference in electronegativity so NaI not as ionic as NaCl.

**c).** i) Permanent dipoles between molecules in ICl but Cl2 has only temporary dipoles / van der Waals forces between molecules.

Permanent dipoles stronger than temporary dipoles / van der Waals forces.

**Or**

ICl larger molecule than Cl2 so more electrons.

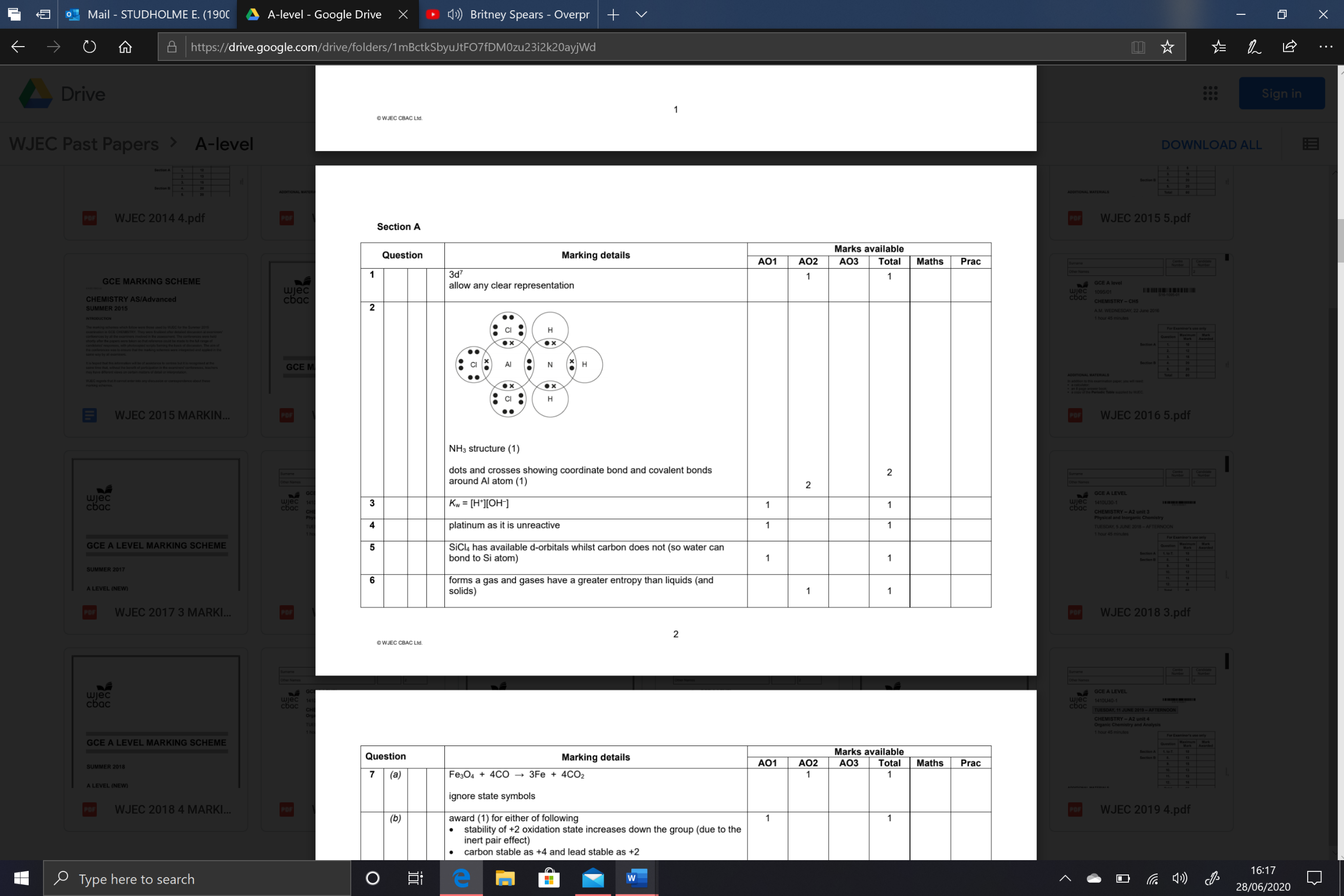
More van der Waals forces between molecules.

**65. 2014. Unit 5. Qn 4b.**

i) Each C atom covalently bonded to three other C atoms forming layers.

Layers held together by weak intermolecular forces.

**66. 2019. Unit 3. Qn 2.**



NH3 structure

Dots and crosses showing co-ordinate bond and covalent bonds around Al atom.