Q1.

Question	Expected Answers	Marks
1 (a)	C, E, D, B;	1
(b)	centromeres have divided/duplicated; R. split R. replicated (sister) chromatids/(daughter) chromosomes pulled/moved/ separate/migrate to (opposite) poles; ref. to the spindle/microtubules/spindle fibres; R. fibres	max 2
(c)	replication/DNA synthesis; assembly of nucleotides/polynucleotide (chain) formed; (alongside) old/original/both strands, act as template; by base/complementary pairing/ A-T and G-C; quantity of DNA doubles/two new double helices formed;	max 3
(d)	production of genetically identical cells/genetically uniform cells/ identical DNA/maintains genetic stability/same number and kind of c-somes/no genetic variation;	1
		[Total 7]

Q2.

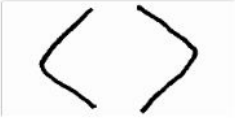
3 (a) (i) 6 ; [1]

(ii) centromere ;

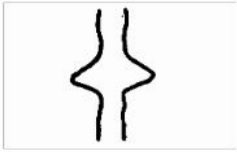
site of attachment to, microtubules/spindle fibres ;
A holds chromatids together **R** ref to centromeres dividing [2]

(iii) any pair shaded in ; **A** more than one pair [1]

(iv) *either*



or



two daughter chromosomes shown ;
centromeres leading as shown above ; [2]

(b) chromosome, unravels/becomes chromatin/AW (during telophase) ;
transcription ;
described/mRNA produced ;
replication/new DNA produced ;
semi-conservative/description e.g. unzips and bases pair up ;
ref to histone proteins ; [max. 3]

(c) halved/6 -> 3 ; A diploid -> haploid/2n -> n

to restore diploid number at fertilization/
to avoid chromosome number doubling in every generation ; [2]

[Total: 11]

Q3.

(b) (during), mitosis / meiosis / nuclear division ; ignore 'cell division' / phases
replicate, after / before, each division ; **A** at interphase
move / separate, to poles ;
assemble / organise, microtubules ;
centre for growth of / forms, spindle fibres / for formation of spindle / AW ;
modified centrioles found elsewhere such as in flagella / cilia ; [3 max]

Q4.

6 **(a)** chromosomes / chromatids, on equatorial plate / at equator / AW ;
A in, centre / middle, of cell
nuclear, membrane / envelope, dispersing / breaking up / (partially) visible / AW ;
A disappearing
chromosomes, in one group / not in two groups / not arrow shaped / not going to poles / not separated / AW ;
R chromosomes at poles [2 max]

(b) smoke / tar, is carcinogenic / contains carcinogens ; **A** named carcinogen e.g. benzpyrene / phenol
genes control, cell division / mitosis ;
mutation / change to DNA (in these genes) ; **A** DNA damaged **A** ref. to mutagenic
gene expression affected / AW ; e.g. ref to oncogenes / proto – to onco – / tumour suppressor genes switched off
cells, grow / divide, uncontrollably / continuously ; **A** uncontrolled mitosis
cancer cells do not respond to signals ;
(and) form a (malignant) tumour ;
(tar) settles on bronchial, epithelial cells / epithelium ; [4 max]

(c) idea of, a long time gap / years, qualified ; e.g. before symptoms of, cancer / tumour, appear between decreased number smoking and lower mortality rates
correct ref. to data to support above ; *trends must be anchored in both graphs*
if data is used, must be anchored in both graphs and numerically correct
increasing mortality rate
increase in lung cancer deaths linked to rise in smoking in 1930s+ ;
valid ref. to other direct risk factors (for lung cancer) in 1930s+ ; e.g. air pollution, mass chest X-ray screening

decreasing mortality rate because
earlier diagnosis (so fewer die) ;
improved, health care / treatment (extends life) ;

ref. to epidemiological evidence linking smoking and lung cancer / almost all cases of lung cancer, are caused by smoking / occur in smokers ; [3 max]

[Total: 9]

Q5.

1 **(a)** **A =** anaphase ;
B = prophase ;
C = metaphase ; [3]

(b) ref. newly formed / daughter cells (following, telophase / mitosis) ;
cells, entering / at early interphase ;
cells, at synthesis stage / making proteins ;
cells growing (to, mature/normal, size) *or* cells not grown to, mature / normal, size ; AW **R** not elongated [max 1]

(c) *any 2 relevant e.g.*
cells metabolically active / AW ;
protein synthesis ;
transcription ;
translation ;
gene expression ;
DNA / semi-conservative, replication ;
respiration ;
synthesising, organelles / named organelle(s) ; e.g. **A** centrioles replicate
synthesising, macromolecules / named macromolecule ; [max 2]

[Total: 6]

Q6.

1 (a) (i) metaphase ; [1]

(ii) chromosomes / (sister) chromatids, line up at the, equator / equatorial plate / metaphase plate ; **A** move to **I** middle / centre
centromeres attached to, spindle / spindle fibres ;
A (spindle) microtubules **A** kinetochore
centrioles, reach / located at / AW, poles ; **R** ends
ref. spindle fully formed ; **A** spindle fibres extend from poles / AW
R ref. to nuclear envelope absent (in anaphase also) [max 3]

(b) replacement of cells ;
repair of tissue ; **R** repair of cells
growth / increase in cell numbers ;
asexual reproduction / vegetative propagation ; **R** cloning
maintains / same, number of chromosomes ; **A** two sets of chromosomes / diploid / 2n
genetically identical to parents ;
A produces daughter cells that are genetically identical **A** ref. clone(s)
ref to rejection / self vs non-self ; [max 3]

(c) ref. coordination of growth / limiting growth ;
ref. minimising exposure to mutations / alterations to DNA (during replication) / AW ;
prevent tumour formation ; **A** prevent, cancer / uncontrollable growth
effect of, tumour / cancer ; e.g. compress other organs / invades other tissues or organs
AVP ; e.g. example of timing of cell cycle linked to cell function / idea of producing cells when required [max 2]

[Total: 9]

Q7.

(b) (i) 1 part of the immune response ; **A** primary / secondary, response

many plasma cells
2 to produce high, concentration / level / AW, of, antibody / immunoglobulin ;
3 (high concentration antibody so) more effective against pathogens / AW ;

identical plasma cells
4 specific / particular / AW, to an, antigen / epitope ;
in context of antibodies or plasma cells
5 antibody (molecules) produced are all the same ; **A** ora, qualified
6 only the gene coding for particular antibody, switched on / transcribed / expressed ; [max 3]

(ii) *accept from annotated diagrams*

cell cycle stages are not required for mark points 1, 3, 4 and 7
reject if incorrect mitotic stage given for these mark points

1 ref. to, duplication / replication, of centrioles (in late interphase / before prophase);
A dividing
R splitting
2 (centriole pairs) move to opposite poles in prophase ;
accept asters or centrosomes for centrioles
3 (movement allows) spindle formation / organisation of spindle fibres / microtubule assembly / microtubule organisation / AW, (in prophase) ;
4 (late prophase / early metaphase / metaphase), chromosomes / centromeres, attach to, spindle fibres / microtubules ;
5 chromosomes, line up / aligned / AW, at, equator / metaphase plate ;
6 ref. separation of, sister / identical, chromatids, at anaphase (to poles) ;
A sister chromatids move to opposite poles at anaphase
A daughter chromosomes *for sister chromatids*
7 ref., pulling / shortening, by, microtubules / spindle fibres ; AW [max 4]

Q8.

6 **(a)** ref. to mutation(s) ;
in context of initiating uncontrolled mitosis OR as a consequence of uncontrolled mitosis
proto-oncogenes convert to oncogenes / oncogenes switched on / tumour suppressor genes switched off ;
(cell division is by) mitosis ;
formation of, tumour / mass of (unspecialised) cells ;
no response to (extracellular / intracellular) signals to control mitosis / AW ;
no contact inhibition / AW ;
no cell death / no apoptosis ;
immune system does not recognise the cells as foreign and destroys them ;
A reference to, not non-self / self
metastasis / described ; [max 3]

(b) **R** way in which cancer develops / epidemiological evidence
A beagles for dogs

1 tar painted on skin of, mice / rabbits / rats / (small) mammal, led to development of (cancerous / malignant) tumour ;
2 dogs that smoked (plain) cigarettes developed, cancer / tumour ;
3 dogs that smoked filter-tipped cigarettes did not develop cancer / tumour ;
A developed precancerous changes
4 control group / dogs, which did not smoke and did not develop, cancer / tumour ;
5 AVP ;
e.g. evidence from any other named mammal
e.g. inhaling substances from, tar / tobacco [max 3]

(c) *similarities*

1 all (named) countries, increase and decrease / reach a peak and decrease ;

differences

2 peaks / AW, have occurred at different years in at least two countries ;
3 all maximum mortality rates are different ;
4 any comparative, data quote / calculation, with units given at least once ;
e.g. dates and mortality rates for at least two countries
e.g. mortality rates for one country at two different dates [max 3]

accept a range or a single figure within the ranges given

countries	**peak mortality rate**	**year**
USA	53–57	1984–1990
Spain	45-48	1993–1997
Finland	69–71	1970–1973
UK	72–75	1970–1975
Hungary	83–87	1996–2000

[Total: 9]

Q9.

1 **(a)** **(i)** *if one box of a pair left blank, no mark for that row*
mark first on row unless one row left completely blank

	mitosis	*meiosis*
1	diploid / two chromosome sets / 2n	haploid / one chromosome set /n ;
2	same number of chromosomes as parent / AW	half the number of chromosomes as parent / AW ;
3	two, copies / alleles / forms, of each	one, copy / allele / form, of each ;
4	(cells) genetically identical (to, each **A** (cells have) same / AW, DNA / **A** no genetic variation	(cells) genetically different **A** (cells have) different / AW, DNA / genetic material **A** genetic variation ;

[max 2]

(ii) **1** for sexual reproduction ; **A** for, gamete / sperm and egg / pollen and ovum, formation *or* **A** gametogenesis

2 to produce, haploid cells / cells with one set of chromosomes, for, fertilisation / fusion ; **A** to form zygote
A cells with half the number of chromosomes for, fertilisation / fusion

3 restores / AW, diploid / original, number when, fertilisation / fusion (of gametes) occurs ; *only need ref. to fertilisation / zygote once*

4 *idea of* ploidy consequences at fertilisation if not ;
e.g. ref. to doubling of chromosome number of original

5 ref. genetic variation, linked to evolution / natural selection; [max 2]

(b) **(i)** 13 μm ; ; *two marks for correct calculation*
(39 000 / 3000)
allow one mark
if calculation of 12.6 μm or 13.3 μm (i.e. measured as 38 mm or 40 mm and not rounded to nearest micrometre)
measurement of, 39 mm / 3.9 cm, incorrectly converted to μm but correct formula used (i.e. divided by 3000) [2]

(ii) *assume cancer cell unless stated otherwise*
(undergoing) uncontrolled, mitosis / division ; **A** fast / rapid / abnormally

mitochondria, provide / produce, ATP ; **R** ATP energy
A provide energy **R** produce energy

RER, produce / synthesise / make / AW, (more), proteins / enzymes, for (cell) growth / mitosis / division ; *if mp 1 gained, no need ref. to mitosis* [max 2]

[Total: 8]

Q10.

5 **(a)** growth (by increase in cell number) ;
production of genetically identical cells ;
replacing (damaged) cells ;
repair (of tissue) ; *allow 'regeneration' if mp3 and mp4 not awarded*
R repair cells
asexual reproduction ;
A cloning **A** vegetative propagation [max 3]

(b) one tick in each box ; [1]

(c) appearance of chromosomes / condensation of chromatin / AW ;
chromosomes visible as two, sister chromatids / chromatids joined by a centromere ;
spindle formation / spindle fibres form / microtubules assemble / AW ;
centrioles, move to / reach, opposite poles ;
R sides / ends
disappearance of nucleolus ;
disassembly / breakdown of, nuclear envelope ;
A nuclear membrane [max 4]

(d) mitosis / prophase, will begin again, too soon / immediately ;
uncontrolled / repeated, cell division / mitosis ;
ignore (risk of), tumour formation / cancerous growth
ref. to consequences on the timing of the cell cycle ; [max 3]

[Total: 11]

Q11.

4 **(a)** *ignore references to prophase*
at D/during metaphase

chromosomes arrange, on metaphase plate/at equator/on equatorial plate; **R** middle of cell
chromosomes with two (sister) chromatids/AW;
chromosomes attached to spindle at centromeres; **[max 2]**
at E/during anaphase

centromere(s), break/divide/duplicate; **R** replicate/split chromosomes/ chromatids, move/separate to opposite poles; **R** ends
ref microtubules/spindle (fibres), with centromeres leading;

[max 2]

(b) chromosomes uncoil/AW; e.g. become longer and thinner
nuclear, membrane/envelope reforms/AW;
new cell membrane formed;
cell plate/(new) cell wall/middle lamella, forms;
cytokinesis; **R** if say cytoplasm constricts as ref to animal cells **[max 3]**

(c) mitotic index decreases from 0.11 to 0.016, as distance from tip increases/from 0.1 to1.9mm;
any ref to comparision plus distance from tip figs ;;
e.g. steep/AW decrease 0.6 to 0.7 mm
small/AW decrease 0.7 to 1.3 mm
slight/AW increase 1.3 to 1.8 mm
A for 1 mark if describe main pattern plus 2 overall ref points
R rapid or slow increases and decreases
if mm not used at least once, penalise once **[max 3]**

(d) during, interphase/S phase/before, mitosis/prophase, replication of DNA;
semi-conservative replication;
some ref to base pairing/any example, to template strand;
(during anaphase), sister chromatids are separated/move to opposite poles/go into separate cells";
new cells have same number, and kind of chromosomes/AW e.g. same, genes/DNA/chromosomes as parents; **[max 3]**

[Total: 13]

Q12.

1 **(a)** no membrane-bound organelles / no named organelle(s) ;
murein / peptidoglycan, in cell wall ;
smaller / 70s / 18nm, ribosomes ;
no nucleus / no nucleolus / no nuclear envelope ;
loop of DNA / circular DNA / no chromosomes / naked DNA / no histones ;
mesosome ;
plasmid ;
capsule ; **A** slime / mucilage, around cell wall ; [3 max]

(b) **(i)** growth ;
repair ;
regeneration ;
replacement / renewal ;
asexual / vegetative, reproduction / propagation ; **[3 max]**

(ii) *idea that* identical / sister chromatids, separate (in anaphase) ;

identical because
semi-conservative replication ;
base pairing / A – T and C – G ;
idea that each, strand / polynucleotide, of DNA acts as a template ;
two double helices produced are identical ;
cells have same, genotype / alleles / DNA / number and kind / set of chromosomes ;
no valid aspect of meiosis ; [3 max]

[Total: 9]

Q13.

3 **(a)** **(i)** anaphase / early telophase ; [1]

(ii) **1** chromosomes / chromatids, move to / at, poles / centrosomes ;
2 attached to, spindle / microtubules ;
3 by, centromeres / kinetochores ; **A** centromeres leading
4 pulled by, microtubules / spindle fibres / AW ;
A contracting / shortening / disassembling [2 max]

(iii) *these points are independent*
1 cannot follow, movement of chromosomes / AW ;
e.g. 'processes in mitosis'
2 can only view dead material ;
3 sections have to be thin ;
4 overstaining obscures details (of chromosomes) ; **A** artefacts
5 cannot see, all of the chromosomes / whole chromosomes ; [2 max]

(b) **(i)** **1** carcinogen / cancer-causing / named carcinogen (in tobacco smoke / tar) ;
e.g. benzpyrene / phenol / nicotine *check any others*
2 mutation / change to DNA ;
3 ref to named gene ; e.g. oncogene / tumour suppressor
4 in (bronchial) epithelium ;
5 uncontrolled, cell division / mitosis / cell cycle ; **R** 'rapid'
6 grows into, mass of cells / lumen of airway(s) / lung tissue ;
A squeezes against blood vessels / enters lymphatic vessels
7 growth of blood capillaries (into tumour) ;
A angiogenesis / vascularisation / ref to thrombospondin
8 no programmed cell death ; [3 max]

(ii) must be a sign or symptom
1 coughing up blood ;
2 persistent cough / coughing a lot ;
3 coughing up increased volume of sputum / AW ;
4 chest / shoulder / back, pain ;
5 wheezing / breathlessness / breathing difficulty ;
6 weight loss ;
7 AVP ; e.g. fatigue **R** tiredness [2 max]

[Total: 10]

Q14.

3 **(a)** so they have the same number of chromosomes (as parent cell) ;

idea that cells would be rejected (if genetically different) ;
ref. to role of the immune system in removing genetically different cells ; [2]

(b) *reject 'smoking' or 'radioactive transmissions' unqualified*

(chemical) carcinogen(s) / named ;
any two named chemical carcinogens to max 2 if term carcinogen not used
e.g. benzpyrene / ethidium bromide / phenol / tar *check any others*

UV ;
X rays ;
ionising radiation ;
gamma rays ;
radon ;
virus(es) / correctly named virus ; **A** HIV / HPV / HTLV / HSV **R** named disease
genetic / hereditary, factors ; [2 max]

(c) **(i)** cytokinesis ; [1]

(ii) chromosomes, uncoil / become diffuse / decondense / AW ;
A chromosomes unwind / become long and thin
A chromosomes become chromatin
A cell enters interphase
spindle breaks down / microtubules disassemble / AW ; **R** disappears

nuclear envelope, reforms / forms / forming ; **A** nuclear membrane **R** (re)appears
nucleolus / nucleoli, reform(s) / forms / forming ; **R** (re)appears

cell membrane, drawn together / furrows / AW ;
idea of role of, microfilaments / AW, in 'drawstring' effect ;

division of cytoplasm / cell separation / cleavage / cleavage furrow develops ;
A cytokinesis *if not credited in* ***(i)***
cell membrane fuses ; [3 max]

(iii) divide / replicate, uncontrollably ; **ignore** quickly / fast
A uncontrolled mitosis **R** grow uncontrollably
do not, differentiate / become specialised ; **A** loss of function
form an (irregular) mass (of cells) / AW ; **A** (a) growth
promotes growth of blood vessels / AW ;
AVP ; e.g. ref to genes / no programmed cell death / loss of contact inhibition [2 max]

[Total: 10]

Q15.

4 **(a)** **(i)** chemical carcinogens ; **A** *named carcinogenic chemical e.g.* asbestos / tar / benzpyrene / aniline dyes / mustard gas / ethidium bromide ; *allow two named chemicals for two marks*
virus, qualified ; e.g. with oncogene / ability to convert host proto-oncogene / named virus e.g. HPV / retrovirus / HIV / HTLV
ionizing radiation / X-rays / gamma rays / particles from radioactive decay / ultraviolet light / alpha particles / beta particles ;
allow two named radiation examples for two marks
free radicals ;
hereditary predisposition / AW ;
tobacco smoking ;
obesity ; **A** qualified ref. to diet
AVP ; e.g. if immunocompromised [max 2]

(ii) not transmissible from one person to another / AW ;
not caused by a pathogen ; **R** bacterium / virus / fungus / AW / 'worm' [max 1]

(b) both drugs effective in treating tumours (compared to no drug) ;
comparative data quote, both drugs compared to no drug ;

ref. T138067 more effective than vinblastine against, tumour A (after day 18) / tumour B / both tumours (A and B)
relevant comparative data quote ; e.g. volume of 220 v 160 mm^3 at day 25 for tumour A
little difference in effectiveness between vinblastine and T138067 against tumour A up to day 18 ; AW
ref. similar effectiveness against tumour B until after day 15 ;
ref. to effectiveness of both drugs detectable from about 7–10 days ; AW
both drugs, not completely effective in stopping growth / tumours continue to grow ;
AVP ; e.g. greater effectiveness of, T138067 with B / vinblastine with A [max 4]

(c) ref. growth of tumour involves mitosis ; **A** cell division
not simple enlargement of cells / AW ;
mitosis stops / metaphase → anaphase → telophase, cannot proceed ;
accept two named stages
ref. to role of spindle during stages of mitosis ; ;
e.g. (prophase) to attach to chromosomes
(metaphase) to align chromosomes
(anaphase) to separate chromatids
} *if stage named, must be correct*
no separation of chromatids at centromere ;
AVP ; e.g. detail of assembly of microtubules
ref. apoptosis when cell cycle disrupted [max 3]

[Total: 10]

Q16.

3 (a) (i) **K** – (DNA) replication / synthesis / described ;
L – cytokinesis / cytoplasmic division / cell division ; [2]

(ii) 3 ; [1]

(iii) remain the same / stays constant / stay at 46 / AW ; *ignore description of events occurring before and during mitosis* [1]

(b) transcription (of specific genes) ; **A** reference to gene switching
protein / polypeptide, synthesis ; **A** translation
production of haemoglobin ;
further detail ; e.g. assembly of quaternary structure
(production of) carbonic anhydrase ;
loss of, mitochondria / named organelles ;
loss of nucleus ;
adopts biconcave disc shape ; [max 3]

(c) occurs in both primary and secondary (immune) responses ;
selected / specific / AW ;
lymphocytes / B -cells / T-cells / divide (by mitosis) ;
clonal expansion / described in terms of producing, clone / many cells ;
A *idea that* different types of immune cell can result
reference mitosis in memory cells (for rapid) secondary response ; [max 3]

Q17.

1 (a) (i) prophase ;
R prophase I [1]

(iii) two homologous chromosomes shaded ; [1]

(iii) centriole ; **A** centrosome / microtubule organising centre / MTOC

one from
produces spindle / produces spindle fibres ;
produce / organises, microtubules ;
disassembles / AW, spindle / spindle fibres / microtubules ; [max 2]
A one e.g. of role of, spindle fibres / microtubules *if a link to centriole has been made*
allow if centriole incorrectly named or if not given

(b) *max 2 if no attempt made at both **X** and **Y***

***X** / cell surface membrane*

1 forms a (cleavage) furrow ; **A** 'pinches in' / constricts / AW
2 ref. fusion ;
3 to divide cell into two ; **A** *idea of* formation of two (separate) cells linked to behaviour of (cell surface) membrane;

4 ref. to cytokinesis / contractile ring ;

Y / *nuclear envelope*

5 disassembles / breaks down / AW ;

6 during prophase / by end of prophase / before metaphase ;
A by the end of prometaphase

7 re-forms / AW, during telophase (from ER) ; [max 3]

[Total: 7]

Q18.

(d) (i) *(produce genetically identical daughter epithelial cells for)*

1 (for tissue) repair ;
R cell repair

2 *idea of* replacing, dead / destroyed / damaged / worn-out / AW, cells ;
A replacement of cells, unqualified *if mp 1 gained*

3 ref. protection of, underlying tissue / muscle and elastic layer / tunica media / AW ;

4 meiosis produces, haploid cells / cells with n chromosomes / cells with one set of chromosomes ;
A cells with half the number of chromosomes

5 meiosis for gamete formation ;
A sex cells
R meiosis in gametes [max 2]

(ii) *ignore ref. to 23/46 chromosomes*

(mitosis to), maintain genetic stability / produce genetically identical cells / produce clones ora
or
meiosis produces genetically different cells ;

(mitosis), ensures cells retain function / cells function as tissue / AW ;
(mitosis) maintains chromosome number ;
A maintains, diploid number / 2n
meiosis produces, haploid cells / cells with n chromosomes / cells with one
A cells with half the number of chromosomes
meiosis for gamete formation ;
A sex cells
R meiosis in gametes [max 2]

(e) *ignore labels*
max 1 if nuclear, membrane / envelope, shown
no marks if chromosomes with two chromatids drawn

1 four separate, chromatids / daughter chromosomes, shown in each half ;

2 all centromeres leading
A 'V' shapes if centromere not obvious *(point of V towards pole)*
or
all centromeres attached to spindle fibres ; [2]

Q19.

3 (a) (i) **R** *if more than one stage given*
A = prophase ; **I** early / late
B = interphase ; [2]

(ii) *no ecf from* **(a)(i)**
I *information about other phases*
1 chromatin / chromosomes / chromatids, condense / become visible ;
A described e.g. coiling, supercoiling, shorten, thicken
2 each chromosome is two (sister) chromatids joined together (at a centromere) ;
R 'two chromatids, join together / pair up'
3 nucleolus disappears ;
4 nuclear envelope, disassembles / breaks down / AW ;
5 centrioles / centrosomes, move to poles ;
A MTOC / microtubule organising centre
R 'ends' / 'sides'
6 ref to spindle ; e.g. spindle (fibres) start to form
centrioles organise microtubules (to form spindle fibres)
microtubules assemble [max 4]

(b) 6 ;;

if answer not given or incorrect allow one mark for correct measurement and correct use of formula

distance between **P** and **Q** is 30 mm, conversion to micrometres = 30 × 1000

either (magnification) = $\frac{30000}{5000}$

or $5000 - \frac{30 \times 100}{\text{actualsize}}$

look carefully for correct use of standard form
allow a tolerance of ± 2 mm (28–32 mm, i.e. 28 000–32 000 in formula) [2]

(c) **I** *general references to LM v EM*
A ora *for electron microscope*

1 living cells can be viewed (with light microscope) ;
2 can watch the cell cycle happen (in real time / time lapse) / AW ;
3 all chromosomes can be seen (at once) ;
4 can see, whole chromosomes / all the stages of mitosis or cell cycle ;
5 do not need take sections to see mitosis ;
6 dyes / stains, can be used ; **I** ref. to natural colours of specimens
A ref. to fluorescence microscopy [max 3]

[Total: 11]

Q20.

(c) *marks can be taken from labels / annotations*
1 chromatids / chromosomes / chromatin, condense / become shorter / become thicker / coil / supercoil / AW ; **A** 'become (more) visible'
2 centrioles, move to / reach, opposite poles ; **R** ends
3 nucleolus disappears ;
4 spindle is formed ; **A** 'more developed' **A** *description in terms of spindle fibres*
5 ref to assembly of microtubules ; **A** 'makes' microtubules **R** 9+2
6 nuclear envelope, disintegrates / breaks down / destroyed / AW ; **A** membrane
7 chromosomes, move to / at, equatorial plate / equator / metaphase plate / AW ; *ignore* middle / centre
8 centromeres attach to, spindle / fibres ;
9 ref to random arrangement of chromosomes ; **A** 'not in pairs' **R** scattered [max 5]