SCNC1112 Fundamentals of Modern Science

THE UNIVERSITY OF HONG KONG · LEVEL 1 · FIRST SEMESTER 2026–27

ONE A4 NOTE SHEET
mechanisms · pathways
rules · key values
SIDE 1 OF 2

Full guide + ask Sia about SCNC1112

SIDE 1/2 EXAM MAP · MECHANISMS · PATHWAYS · CLASSIFICATIONS · KEY VALUES

ONE DOUBLE-SIDED A4 SHEET

45 MCQ · 2 hours · final 45%

1 · Exam map

COURSE PLAN

Tutorial 20 | Project 20 | 3 CMA 15 | Final 45

COMPONENT	WEIGHT	FORMAT
Tutorial participation + homework	20%	9 tutorials + 2 group assignments
Project presentation	20%	10 min, team of four
Three course module assessments	15%	10 MCQ each
Final examination	45%	2 h · 45 MCQ

Students are allowed to bring a double-sided A4 cheat sheet either handwritten or printed to the final examination. *(SCNC1112 course schedule, first semester 2026-27)*

Question modes: fundamental concepts · connect material across the course · apply learning to a novel situation. For every relation, know the *direction*, limiting case and likely distractor.

2 · Motion → force

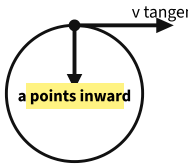
C1

QUANTITY	EXACT MEANING	UNIT
Speed	distance ÷ time	m s^{-1}
Velocity	speed + direction	m s^{-1}
Acceleration	rate velocity changes	m s^{-2}
Force	changes state of motion	N

RELATIONS

$F = ma$ · weight $= mg$ · $F_{grav} = Gm_1m_2/d^2$

Newton: (1) motion persists unless net force acts; (2) more F → more a, more m → less a; (3) forces come in equal/opposite pairs on *different objects*.



constant speed ≠ constant velocity

Guide Fig 1.1 redrawn: turning at constant speed still accelerates.

TRAP *Orbiting = continuous free fall. "Weightless" means no support force, not no gravity.*

2b · One event, three laws

C1

Balloon car: expelled air is pushed backward and pushes the car forward (law 3); that unbalanced forward force changes the car's motion (law 1); its acceleration is fixed by **a = F/m** (law 2). Do not assign an action–reaction pair to the same object.

IF…	THEN…	HELD FIXED
net F ×2	a ×2	mass
mass ×2	a ×½	net force

3 · Inverse-square reasoning

C1 · C8

CHANGE	GRAVITY / STARLIGHT
distance ×2	value ×¼
distance ×3	value ×⅑
one mass ×2	gravity ×2
star output ×25	habitable-band distance ×5

Mass is invariant; weight is a force and changes with g. Hammer + feather land together in vacuum because gravitational acceleration is independent of their masses.

4 · Work, energy, power

C2

$W = Fd$ (along motion) · power = energy/time

1 W = 1 J s^{-1} · 1 food Calorie ≈ 4184 J

FORM	WHAT CARRIES IT	EXAM DISCRIMINATOR
Kinetic	motion	changes with speed
Potential	position/configuration	raised mass, bond, spring
Thermal	random particle motion	temperature = average per particle

Work can be zero while effort is large: a force on a wall that does not move transfers no mechanical energy.

CONDUCTION	CONVECTION	RADIATION
contact collisions	moving fluid circulation	waves no medium

spontaneous heat flow: hot → cold

Guide Fig 2.2 redrawn: identify the route by what it requires.

5 · Entropy boundary

C2

Spontaneous = natural tendency; it says **nothing about speed**. In an *isolated* system, entropy rises. Life builds local order but imports energy and exports heat/waste, so organism + surroundings still gain entropy.

WHICH IS TRUE? *Diamond → graphite may be favourable yet geologically slow: thermodynamics answers "whether"; kinetics answers "how fast".*

5b · Heat / temperature traps

C2

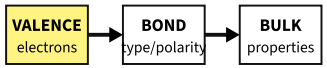
STATEMENT	USE
temperature	average energy per particle
thermal energy	total random particle motion; depends on amount

6 · Atoms → bulk properties

C3

TERM	DECISION RULE
Atomic no.	protons; fixes element
Isotope	same protons, different neutrons
Valence e$^-$	outer shell; controls bonding/reactivity
Ionic	e$^-$ transfer; oppositely charged ions
Covalent	e$^-$ shared; unequal sharing → polar
Metallic	mobile e$^-$ through lattice

Reaction energy: breaking bonds costs energy; forming bonds releases it. Net release means product bonds are collectively stronger. Balance atoms: matter is rearranged, not created.



periodic column repeats outer arrangement

Guide Fig 3.1 redrawn: one explanation across three scales.

7 · Identify bonding

C3 WORKED

OBSERVATION	IONIC SOLID	MOLECULAR COVALENT
Melting point	high lattice cost	lower; weak between molecules
Conducts as solid	no: ions fixed	no free charge
Conducts molten	yes: ions mobile	no
Water solution	often conducts	generally no ions

TRAP *High melting point alone is not decisive; covalent networks can also be high. Pair it with conductivity.*

8 · Water: cause → effect

C4

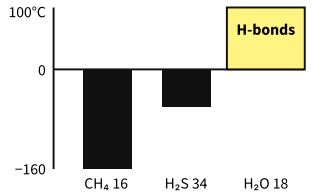
Bent + polar O–H bonds → molecule has charged ends → many hydrogen bonds → high boiling point, high heat capacity, open ice lattice. Ice is less dense, so lakes freeze from the top.

PROCESS	WATER'S ROLE
Dehydration synthesis	remove H_2O per link formed
Hydrolysis	add H_2O to break a link

8b · Evidence → bonding

C3–C4

Use paired observations. A high melting point says attractions are strong; conductivity says whether mobile charge exists. Ionic solids do not conduct while solid because ions are fixed, but conduct molten or dissolved when ions move. A neutral molecular liquid lacks charge carriers.



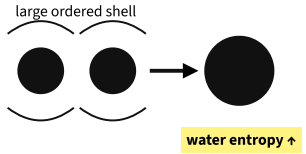
Guide Fig 4.1 redrawn: mass cannot explain water boiling at 100°C.

9 · Solvation & hydrophobicity

C4

SURFACE	WATER CAN…	PREDICTION
Ionic	orient charged ends around ions	dissolves if new attractions pay lattice cost
Polar / O–H	hydrogen-bond	often mixes
Non-polar	no favourable bonds; orders shell	surfaces associate

Oil and water do not "repel". When non-polar surfaces merge, contact area falls and ordered water is released; increased water entropy drives the hydrophobic effect. Same mechanism helps membranes assemble and proteins fold.



Guide Fig 4.2 redrawn: less non-polar area releases constrained water.

10 · pH & buffers

C5

$pH = -\log_{10}[H^+]$ · fall by 1 pH → $[H^+]$ ×10

difference ΔpH → concentration factor $10^{|\Delta pH|}$

Acid donates H^+; **base** accepts H^+; water can do either. A **buffer** absorbs/releases H^+ and reduces the pH move; blood remains near pH 7.4. Clean rain is already near pH 5.6 because dissolved CO_2 forms carbonic acid.

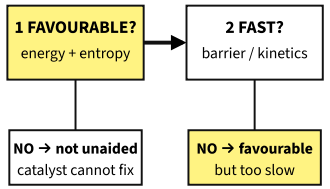
10b · One solvent, four families

C4 · C9

FAMILY	MAIN JOB	MONOMER / ASSEMBLY CUE
Nucleic acids	store/transmit sequence	nucleotide
Proteins	catalyse, signal, transport, structure	amino acid

11 · The two reaction gates

C5



Guide Fig 5.2 redrawn: thermodynamics and kinetics answer different questions.

Catalyst: alternative lower-barrier route; not consumed; changes rate, *not* start/end energy difference. It cannot make an unfavourable change favourable. Enzymes are biological catalysts.

Oxygen reduction: oxygen accepts electrons; strong product bonds release much energy. Flame and respiration share the same overall start/end and total release. Cells use many enzyme-controlled steps to capture energy; flame releases it at once.

12 · Earth: inference & time

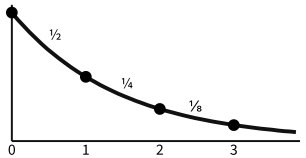
C6

EVIDENCE	INFERENCE
S-wave shadow	liquid outer core: shear waves cannot cross liquid
Mean density > surface rock	dense interior
Iron–nickel meteorites	plausible dense composition
Quake/volcano belts	plate boundaries; mantle convection drives plates

after n half-lives: fraction remaining = $(½)^n$

Clock choice: carbon-14 ≈ 5,700 y half-life; once-living material; useful only to roughly 50,000 y. Uranium–lead: mineral crystallisation and billion-year scales. Assumptions: decay rate constant; starting composition known/recoverable.

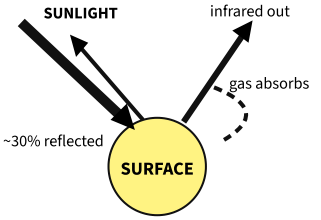
Relative time: lower undisturbed layer is older; a feature cutting layers is younger than them. Always name the dated event, not merely the event you care about.



Guide Fig 6.2 redrawn: the fraction halves each interval and never reaches zero.

13 · Climate accounting

C7



Guide Fig 7.1 redrawn: temperature settles where absorbed input equals output.

No-atmosphere estimate ≈ **255 K**; observed global mean ≈ **288 K**; difference ≈ **33°C** = natural greenhouse effect. Adding infrared-absorbing gas shifts the balance to a hotter surface.

Ice feedback: warming → reflective ice melts → darker ocean absorbs more → further warming. Tropics have surplus, poles deficit; air, ocean and latent heat transport energy poleward.

14 · Earth in space

C7–C8

CLAIM	DISCRIMINATOR
Distance causes seasons	false: hemispheres have opposite seasons at same distance
Axial tilt causes seasons	≈23.4° changes beam angle + day length oppositely
In habitable zone ⇒ water	false: atmosphere also matters; Venus/Mars
Massive star lives longer	false: luminosity rises faster than fuel mass

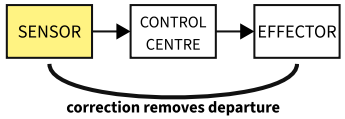
habitable distance ∝ √(stellar output)

stellar lifetime ≈ fuel/consumption ≈ mass/luminosity

15 · Life → evolution

C9–C12

SYSTEM	CORE CAUSAL CHAIN
Protein	sequence → folding → shape → binding → function
DNA	base pairing → each strand templates its partner
Expression	DNA → mRNA → protein; cell types read different genes
Homeostasis	sensor → control centre → effector → opposing return



Guide Fig 11.2 redrawn: negative feedback is a process, not a fixed state.

SCNC1112 Fundamentals of Modern Science · Exam Drills

WORKED APPLICATIONS · WHICH-IS-TRUE CONTRASTS · SHORT-ANSWER FRAMES · FAST RECALL

ONE A4 NOTE SHEET
compute · explain
reject distractors
SIDE 2 OF 2

Full guide + ask Sia about SCNC1112

SIDE 2/2 WORKED APPLICATIONS · MULTIPLE-CHOICE TRAPS · SHORT-ANSWER FRAMES · FAST RECALL

TRACE EVERY CLAIM TO A MECHANISM

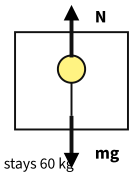
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16 · Lift: mass ≠ scale reading

C1 WORKED

Given: m = 60 kg, g = 9.8 m s^{-2}, upward a = 2 m s^{-2}. The scale reads support force N, not mass.

CASE	EQUATION	READING
stationary	N = mg	60×9.8 = **588 N**
accelerating up	N − mg = ma	60(9.8+2) = **708 N**
free fall	N = 0	**0 N**



N changes; m stays 60 kg

Worked-model redraw: identify the instrument's force before calculating.

WHICH IS TRUE? *In free fall gravity still acts; the zero reading occurs because no surface pushes back.*

17 · Shower vs food energy

C2 WORKED

```
shower = mcΔT = 60×4184×25 ≈ 6.3×10⁶ J
food = 2000×4184 ≈ 8.4×10⁶ J
```

Conclusion licensed: same order of magnitude; food slightly larger. **Not licensed:** any claim about cost, efficiency or emissions—none entered the arithmetic.

18 · Physics distractors

C1–C2

FALSE STEM	REPLACE WITH
constant speed ⇒ no acceleration	direction change ⇒ acceleration
third-law forces cancel	they act on different bodies
power = total energy	power = energy per time
spontaneous = rapid	tendency and rate are separate
life violates second law	life is not isolated

18b · Proportion drills

C1 · C8

Gravity: if separation becomes 3d, F becomes F/9; if one mass then doubles, result is 2F/9. Change one factor at a time and multiply effects.

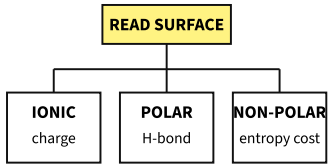
Starlight: received energy follows the same inverse square. To keep the same flux around a star 25× as luminous, distance must be $\sqrt{25} = 5\times$.

Circular motion: "constant speed" fixes only magnitude. The velocity arrow changes direction at every point, so Δv and inward acceleration are non-zero. A vanished inward force would produce a tangent path, not continued orbit.

19 · Three solutes in water

C4 WORKED

SOLUTE	SURFACE OFFERS	PREDICTION + WHY
NaCl	ions	dissolves: charged ends solvate Na^+/Cl^-
Ethanol	O–H group	mixes: donates + accepts H-bonds
Hexane	non-polar C–H	separates: ordered water shell costs entropy



Worked-model redraw: predict by what the solute surface lets water do.

TRAP *"Like dissolves like" predicts but does not explain. Name charge/H-bonding or the entropy of released water.*

20 · Nitrogen → ammonia

C5 WORKED

1. **Feasibility:** the change releases energy → passes thermodynamic gate.
2. **Obstacle:** N≡N gives a high activation barrier → negligible room-temperature rate.
3. **Solution class:** catalyst supplies lower-barrier path; temperature raises fraction of useful collisions.
4. **Limit:** catalyst does not alter energy difference or turn an unfavourable reaction favourable.

Answer frame: "The obstacle is kinetic, not energetic. ___ is favourable, but ___ raises the barrier. A catalyst changes ___, not ___."

21 · pH quick cases

C5

MOVE	[H⁺] CHANGE
6.5 → 5.5	×10
8 → 6	×100
4 → 7	÷1000

More atmospheric CO_2 has two distinct paths: absorbs outgoing infrared → warming; dissolves in seawater → carbonic acid → lower pH.

21b · Two white solids

C3 WORKED

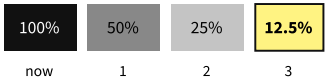
A: melts at 801°C, conducts molten → ionic lattice: strong attractions + mobile ions. **B:** melts at 186°C, never conducts → neutral molecular covalent substance.

22 · Charcoal hearth date

C6 WORKED

Given: 12.5% carbon-14 remains; half-life ≈ 5,700 y.

```
12.5% = ⅛ = (½)³ → 3 half-lives
age ≈ 3×5,700 ≈ 17,000 years
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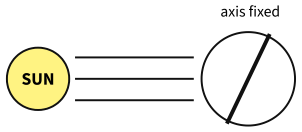
Worked-model redraw: convert the fraction to a power of one half first.

Date belongs to: tree death (carbon uptake stopped), not fire lighting or site occupation. Old/reused timber makes the hearth appear too old.

23 · Refute "distance causes summer"

C7 WORKED

1. **Prediction:** one Earth–Sun distance should give the whole planet the same season.
2. **Observation:** hemispheres have opposite seasons simultaneously.
3. **Reject:** distance cannot cause opposite outcomes at once.
4. **Mechanism:** ≈23.4° fixed axial tilt changes beam angle and day length oppositely.



angle + daylight, not distance

Guide Fig 7.2 redrawn: opposite hemispheres provide the decisive test.

24 · Star lifetime ratio

C8 WORKED

Star A = 10 solar masses; B = 0.5. Lifetime ≈ fuel/consumption. Luminosity rises much faster than mass, so A has 10× fuel but thousands× output and dies in tens of millions of years; B spends slowly and remains after 10 billion years.

TRAP *"More fuel ⇒ longer life" holds only if the consumption rate is fixed.*

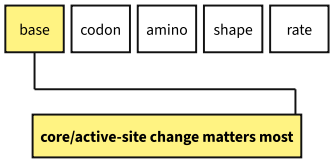
24b · Independent evidence chains

C6–C8

QUESTION	MUTUALLY SUPPORTING OBSERVATIONS
Earth's hidden core	S-wave shadow + high mean density + iron–nickel meteorites

25 · Base change → slower enzyme

C9 WORKED



Guide Fig 9.4 redrawn as the examined causal chain.

1. Substituted base may change one codon and amino acid.
2. Core/active-site substitution can alter local interactions and folding.
3. Distorted active site binds less well → slower catalysis → substrate may accumulate.
4. **No effect if** codon is silent or position does not matter to shape/binding.

TRAP *A DNA change does not guarantee a phenotype; identify exactly where the chain could stop.*

26 · Recessive cross

C10 WORKED

AA × AA	A	A
A	AA unaffected	Aa carrier
A	Aa carrier	aa affected

Per conception: ¼ affected, ½ carriers, ¼ neither. Three unaffected children do *not* change the fourth child's ¼ probability: independent events; the ratio is not a family quota.

27 · Replication evidence

C10

ROUND	OBSERVED BAND(S)	DECISION
start	heavy	labelled parental DNA
after 1	intermediate	rules out conservative; not yet decisive
after 2	intermediate + light	supports semi-conservative

Method mark: predictions for competing models were stated before measurement, and the test continued until they diverged.

27b · What counts as living?

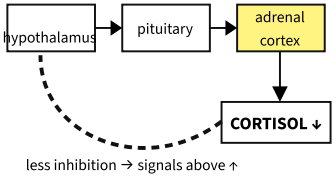
C9

REQUIREMENT	FUNCTION	VIRUS?
active semi-permeable boundary	maintains internal state	borrows host
energy conversion	powers work	borrows host
records + catalysts	information + reactions	sequence record present
open-ended evolution	heritable change	yes

28 · Locate a feedback failure

C11 WORKED

Case: cortisol low; poor between-meal glucose and blood-pressure regulation.



Guide Fig 11.3 redrawn: low product plus high upstream signals locates gland failure.

1. Cascade: hypothalamus → pituitary → adrenal cortex → cortisol.
2. Low final product explains both symptoms; likely adrenal cortex failure.
3. Reduced inhibitory return disinhibits levels above → their signals rise.
4. **Diagnostic contrast:** low product + high signals = gland; low product + low signals = fault higher up.

29 · Feedback / receptor traps

C11

WHICH IS TRUE?	CORRECT CONTRAST
tight binding means activation	agonist binds + activates; antagonist binds + blocks
fever = control failure	set point usually reset higher and defended
positive feedback is always harmful	useful for clotting/ovulation/childbirth with stopping event
negative means the output is low	negative means correction opposes trigger

30 · Cell essentials

C11

Cell theory: all life uses ≥1 cell; cell is smallest organised unit; new cells come only from pre-existing cells. **Membrane:** lipid boundary controls exchange. **Channel** opens a selective path down a gradient; **transporter** binds and changes shape; **receptor** converts external binding into an internal response.

30b · Protein structure ladder

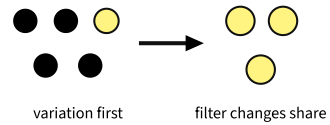
C9

LEVEL	MEANING	FAILURE MODE
Primary	amino-acid sequence	substitution enters here
Secondary	local helix/sheet; H-bonds	local fold altered
Tertiary	whole 3-D chain	active site distorted
Quaternary	several chains assembled	subunits fail to fit

31 · Antibiotic resistance

C12 WORKED

1. Random mutations produced resistance variation before exposure.
2. Antibiotic killed susceptible cells; resistant variants left more descendants.
3. Population composition changed quickly because generations are short.
4. Bacteria did *not* mutate because they needed resistance.

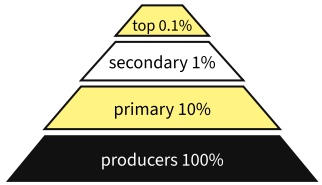


Worked-model redraw: mutation is random; selection is non-random.

Discriminating test: culture independent unexposed lines, then test for resistance. Resistant lines before exposure show variation preceded selection.

32 · Trophic energy

C12



Guide Fig 12.3 redrawn: roughly 10% passes per trophic step.

Rest is lost as heat or spent on maintenance. Consequences: food chains are short; top predators are rare. Species loss may look harmless because redundancy absorbs a role; the **rivet hypothesis** predicts accumulated loss can trigger sudden collapse.

33 · Fast MCQ contrasts

C8–C12

FALSE	TRUE
habitable zone guarantees water	necessary energy range, not sufficient
humans descended from chimps	share an extinct common ancestor
theory = guess	tested framework surviving refutation

34 · Short-answer frame

ALL MODULES

MECHANISM ANSWER

```
Claim → definition/relation →
direction → observation → reject
alternative → assumption.
```


Your exam allows one A4 sheet of notes, both sides. Check on the LMS whether printed notes are accepted; if they must be handwritten, copy it.
First-semester assessment period, 7–23 December 2026 (check your personal exam timetable).