

SI Units Card Deck

General Introduction:

Welcome to the SI Units Card Deck! This interactive educational activity offers a fun way for students to enhance their understanding of the International System of Units (SI), including the Defining Constants, Base Units, Derived Units with Special Names, and Prefixes. With multiple game variations, games may be differentiated for multiple instructional and skill levels.

Learning Objectives:

1. DEMONSTRATE relationships between Defining Constants, Base and Derived Units, and Prefixes.
2. APPLY strategic decision-making during gameplay.
3. COLLABORATE and COMMUNICATE within a team.

Set	Title	Pages	Grade Level		
			3 rd to 5 th	6 th to 8 th	9 th +
A	Defining Constants	3 to 4			✓
B	Base Units Name	5 to 6		✓	✓
C	Base Units Symbol	7 to 8		✓	✓
D	Base Units Quantity	9 to 10		✓	✓
E	Derived Units Name	11 to 16			✓
F	Derived Units Symbol	17 to 22			✓
G	Derived Units Quantity	23 to 28			✓
H	SI Prefixes Name & Symbols, Factors (Large)	29 to 32 33 to 36	✓	✓	✓
	SI Prefixes Name & Symbols, Factors (Small)	37 to 40 41 to 44	✓	✓	✓

Activity Includes: 142 Cards, Game Instructions, Game Template, and Resources.

Keywords: International System of Units, Metric System, Defining Constant, Base, Derived, Unit, Prefix, Measurement, Team, Individual, Game, Play, Collaboration, Activity, Classroom, SI, STEM, Education.

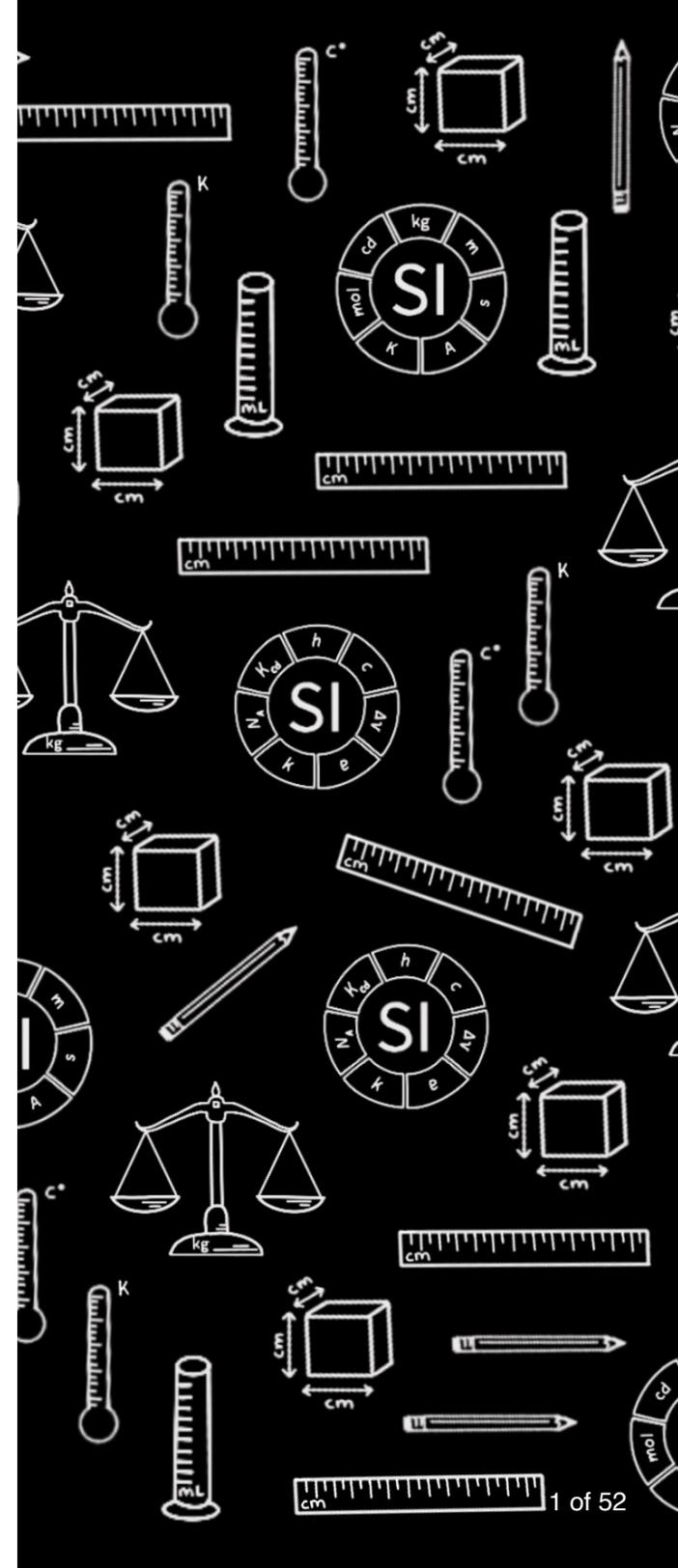


NIST

OFFICE OF
WEIGHTS AND MEASURES

NIST SP 1297 | October 2023
nist.gov/metric

This publication is available free of charge <https://doi.org/10.6028/NIST.SP.1297>



Instructor Guide

Background

Play activities, like those within this resource, are an easy way to motivate students to learn, build self-confidence and transfer SI measurement skills to other situations.¹ Familiarity with the elements and structure of the International System of Units (SI), commonly known as the metric system, will prepare students to successfully make measurements in science, technology, engineering and mathematics (STEM) applications.

The major SI elements are illustrated in this model (**Resource 1**):

- Seven **defining constants**: the cesium hyperfine splitting frequency (ΔV_{Cs}), speed of light in vacuum (c), the Planck constant (h), elementary charge (e) (i.e., the charge on a proton), Boltzmann constant (k), Avogadro constant (N_A), and luminous efficacy of a specified monochromatic source (K_{cd}).
- Seven **SI base units**: the meter (m), second (s), mole (mole), ampere (A), kelvin (K), candela (cd), and kilogram (kg).
- Twenty-two **derived units with special names**, defined as products of powers of the base units.
- Together the base units and derived units with special names (twenty-nine units) form the **core set of SI units**. All other SI units are combinations of some of these twenty-nine units. Any of the base units and derived units with special names can be constructed directly from the seven defining constants. Derived units with **generic names** reflect their mathematical derivation, such as area (m^2), volume (m^3), velocity (m/s), and acceleration (m/s^2).
- Twenty-four **prefixes** ranging from 10^{30} to 10^{-30} , are currently recognized for use. Values of quantities are expressed using Arabic symbols for numbers paired with a unit symbol, often prefix symbol that modifies unit magnitude.

Materials

- U.S. office size card stock 215.9 mm x 279.4 mm (8.5 in x 11 in) or printer paper 215.9 mm x 279.4 mm (8.5 in x 11 in).
- Cutting tools (paper trimmer, paper cutter, or scissors).
- Binder clips and envelopes.

Printing

This game includes 9 card sets. Depending on the planned classroom activity, print the appropriate sets, instructions, and resources.

Cutting

- **Paper Trimmer**: For efficient cutting, use a paper trimmer. Place up to 3 sheets of card stock in the trimmer and ensure proper alignment. Cut along designated lines to create individual cards. This method yields precise results (about 5 minutes per set).
- **Paper Cutter (Guillotine)**: Utilize a paper cutter for cutting larger batches of card sheets at a time. Carefully align the stack of card stock, then lower the guillotine blade to cut along the lines. This method is suitable for cutting multiple cards simultaneously with clean edges (about 3 minutes per set).
- **Scissors**: Carefully cut along the lines on each sheet separately. This method is ideal for smaller batches or when no other cutting tools are available (about 15 minutes per set).
- **Safety**: Keep fingers clear of cutting areas.

Storage

- Organize each set with a binder clip. This prevents cards from getting mixed up and makes it easy to distribute decks during gameplay.
- Store each complete deck within a labeled envelope. The envelope should contain the cards, accompanying game instructions, and resources for easy reference.

Teaching Tips

- Introduce the elements and structure of the SI prior to undertaking this activity.
- Encourage students to use the card deck as a “homework helper” and exam study aid.
- Illustrate how the SI is applied in real-world examples.

SI
Defining
Constants
(Set A)

NIST OFFICE OF
WEIGHTS AND MEASURES

e

elementary
charge

k

Boltzmann
constant

c

speed of light
in vacuum

SI Defining Constants (Set A)

N_A

Avogadro
constant

ΔV_{Cs}

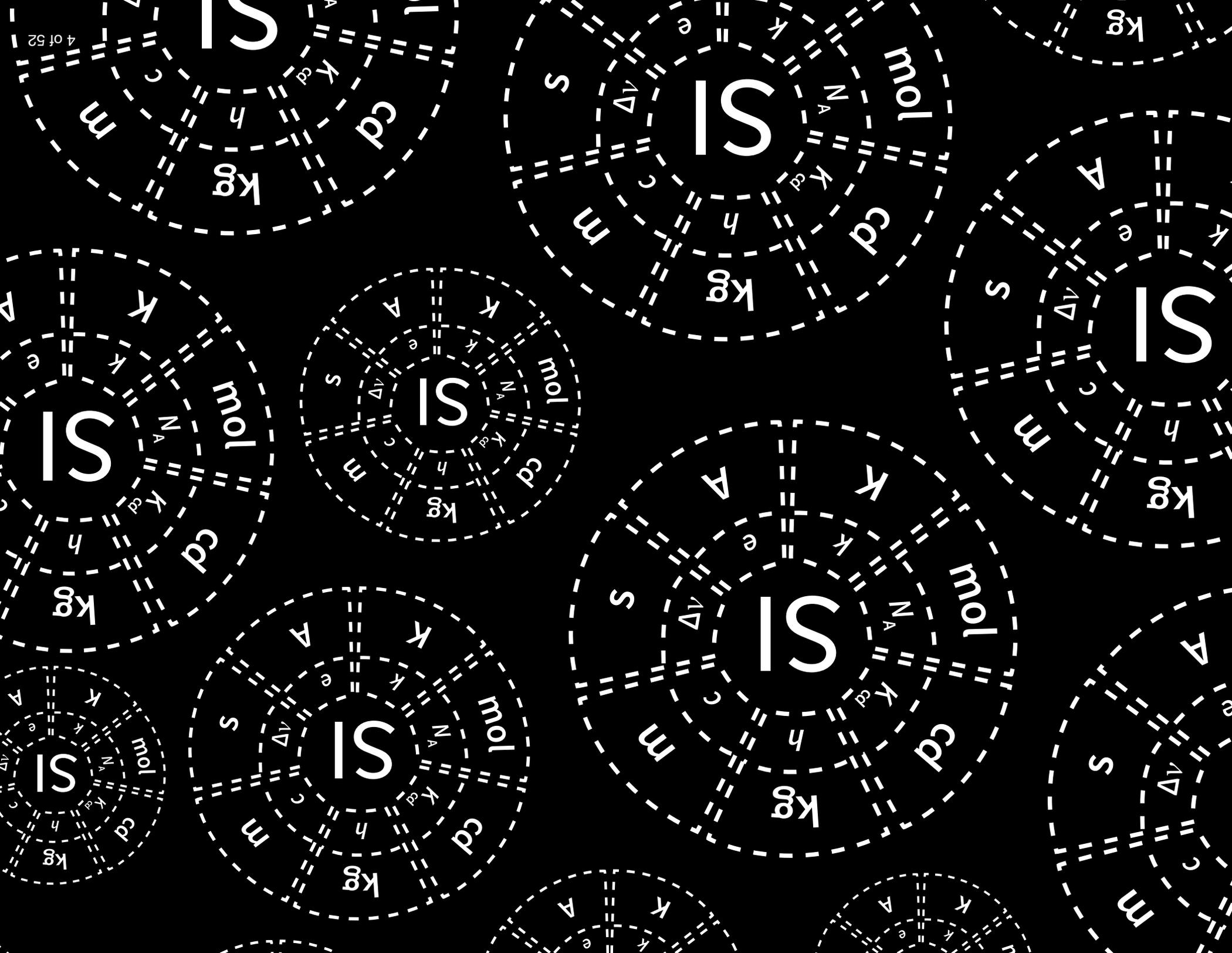
hyperfine
transition
frequency
of Cs

K_{cd}

luminous
efficacy

h

Planck
constant



SI
Base Unit
Name
(Set B)

NIST OFFICE OF
WEIGHTS AND MEASURES

meter

kilogram

ampere

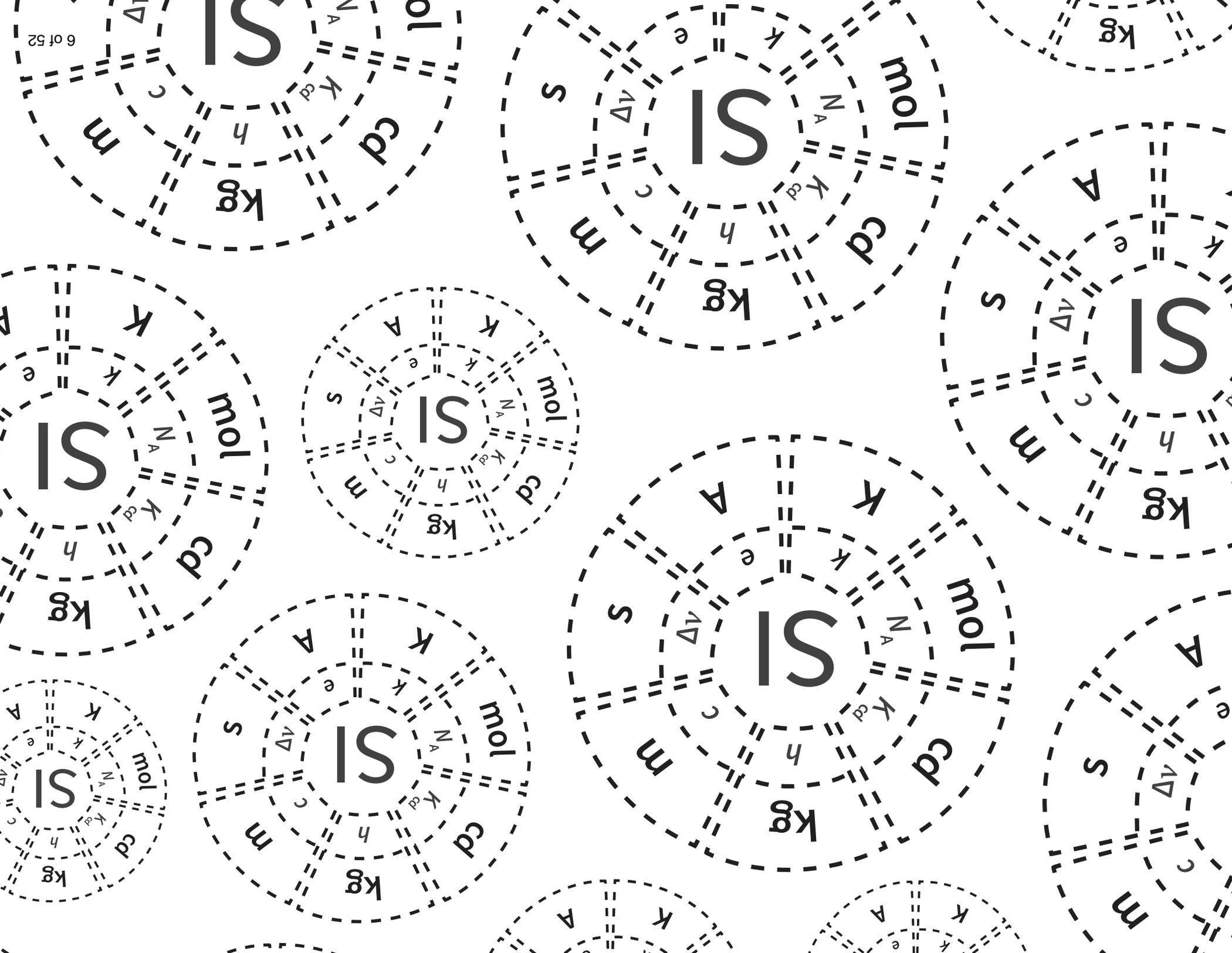
SI Base Unit Name (Set B)

kelvin

mole

candela

second



SI
Base Unit
Symbol
(Set C)



m

kg

A

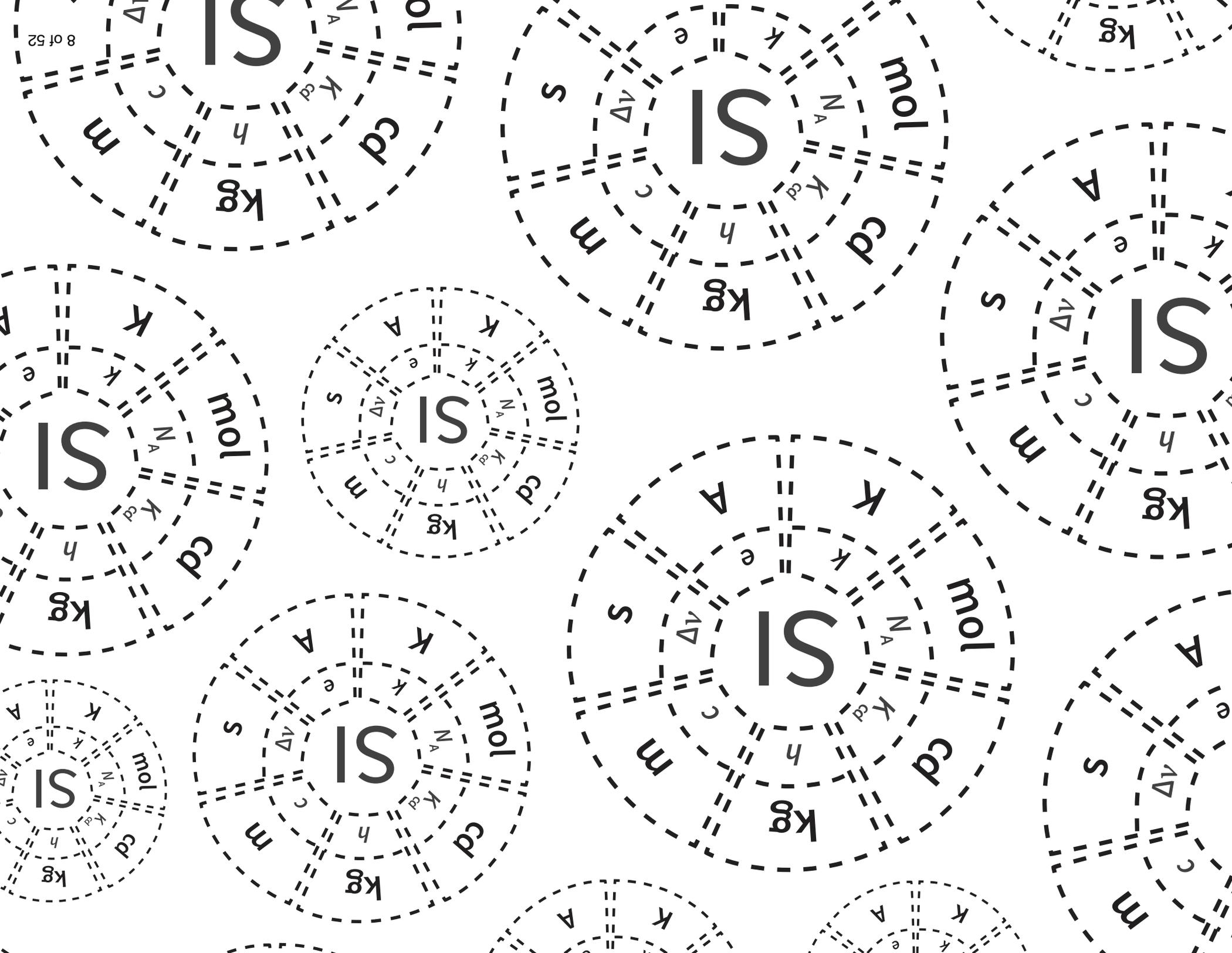
SI Base Unit Symbol (Set C)

K

mol

cd

s



SI
Base
Quantity
Name
(Set D)

NIST OFFICE OF
WEIGHTS AND MEASURES

length

mass

electric
current

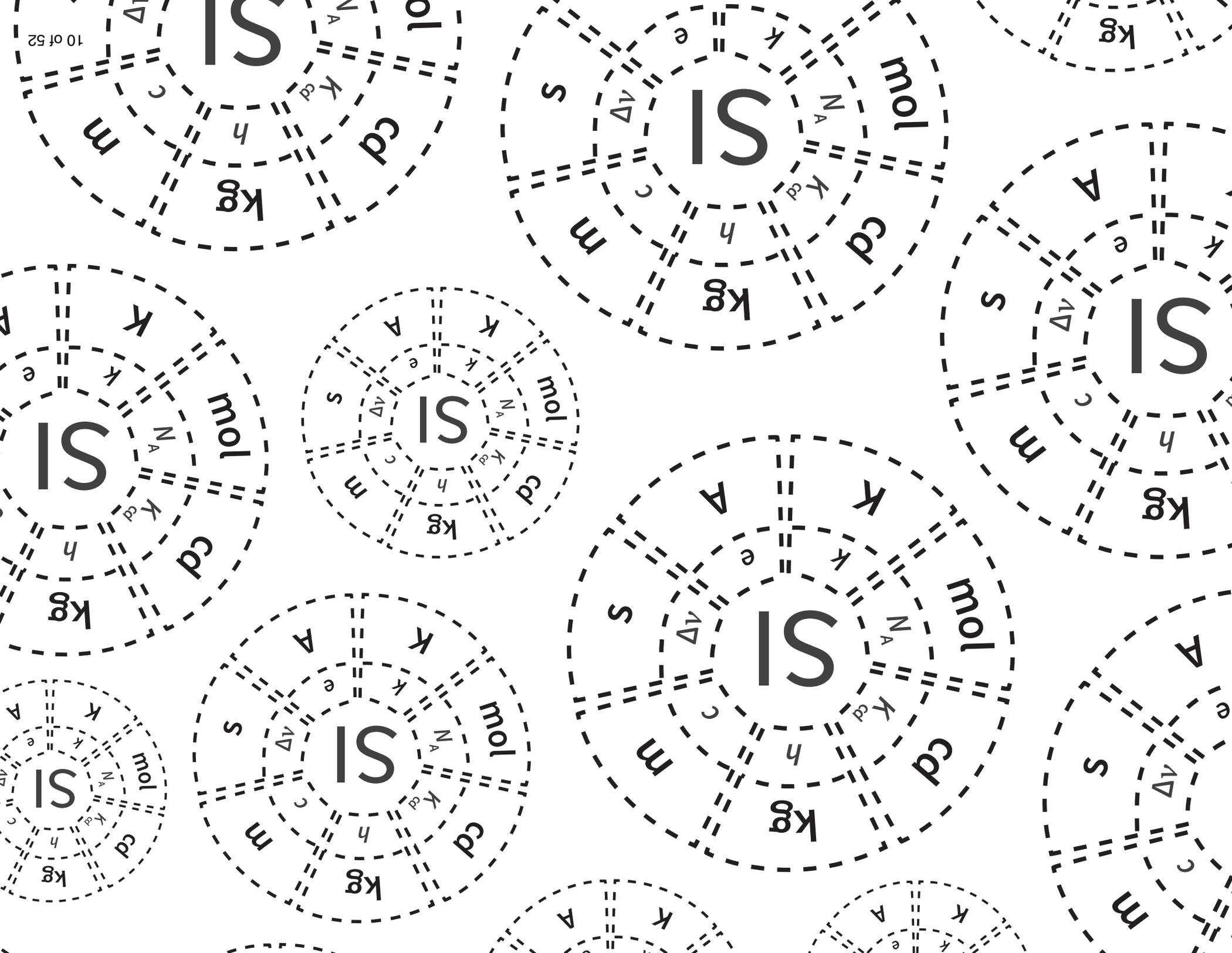
SI Base Quantity Name (Set D)

thermo-
dynamic
temperature

amount of
substance

luminous
intensity

time



SI
Derived Units
with Special
Names
Name
(Set E)

NIST OFFICE OF
WEIGHTS AND MEASURES

joule

newton

coulomb

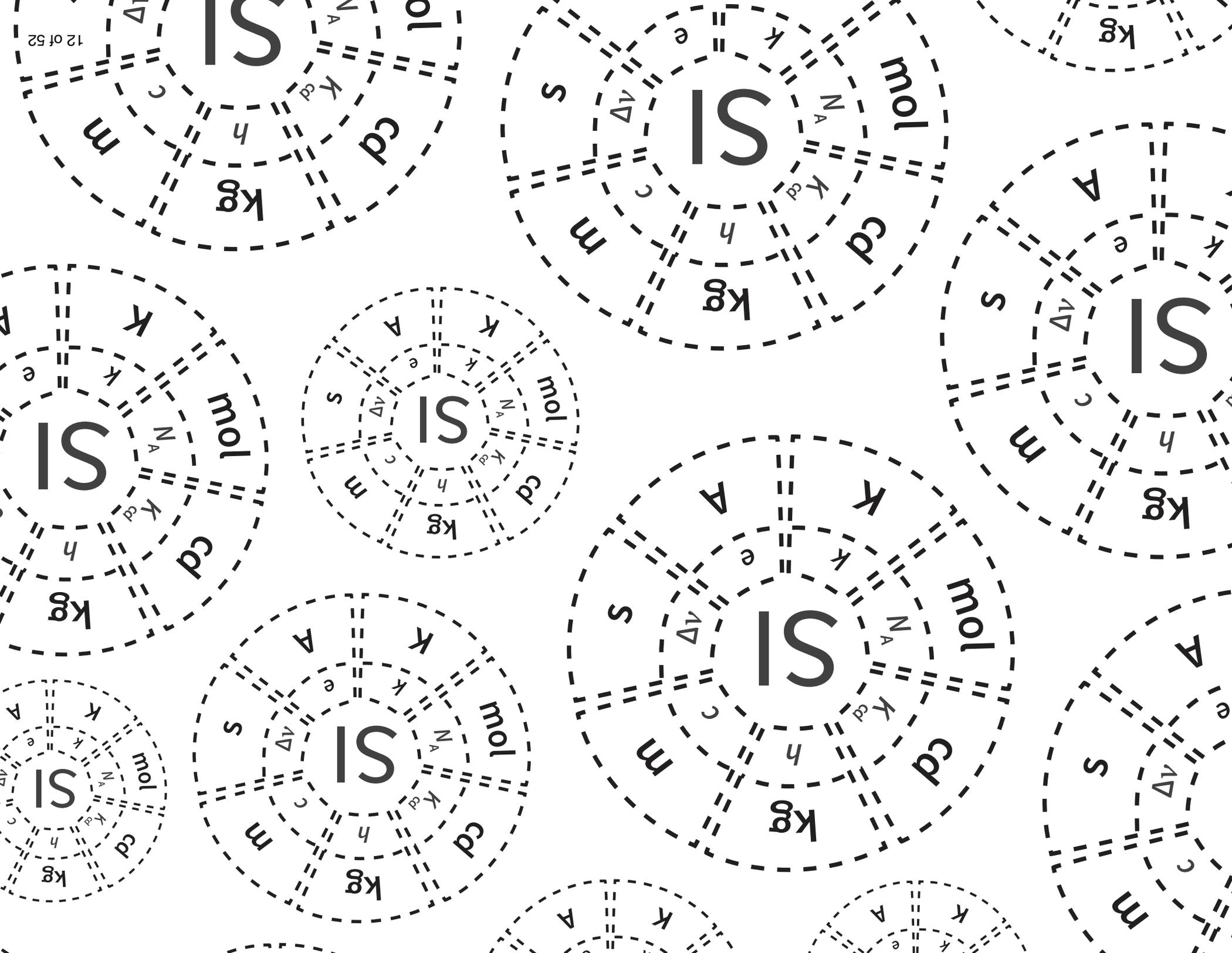
SI Derived Units with Special Names Name (Set E)

degree
Celsius

katal

lux

watt



pascal

volt

weber

tesla

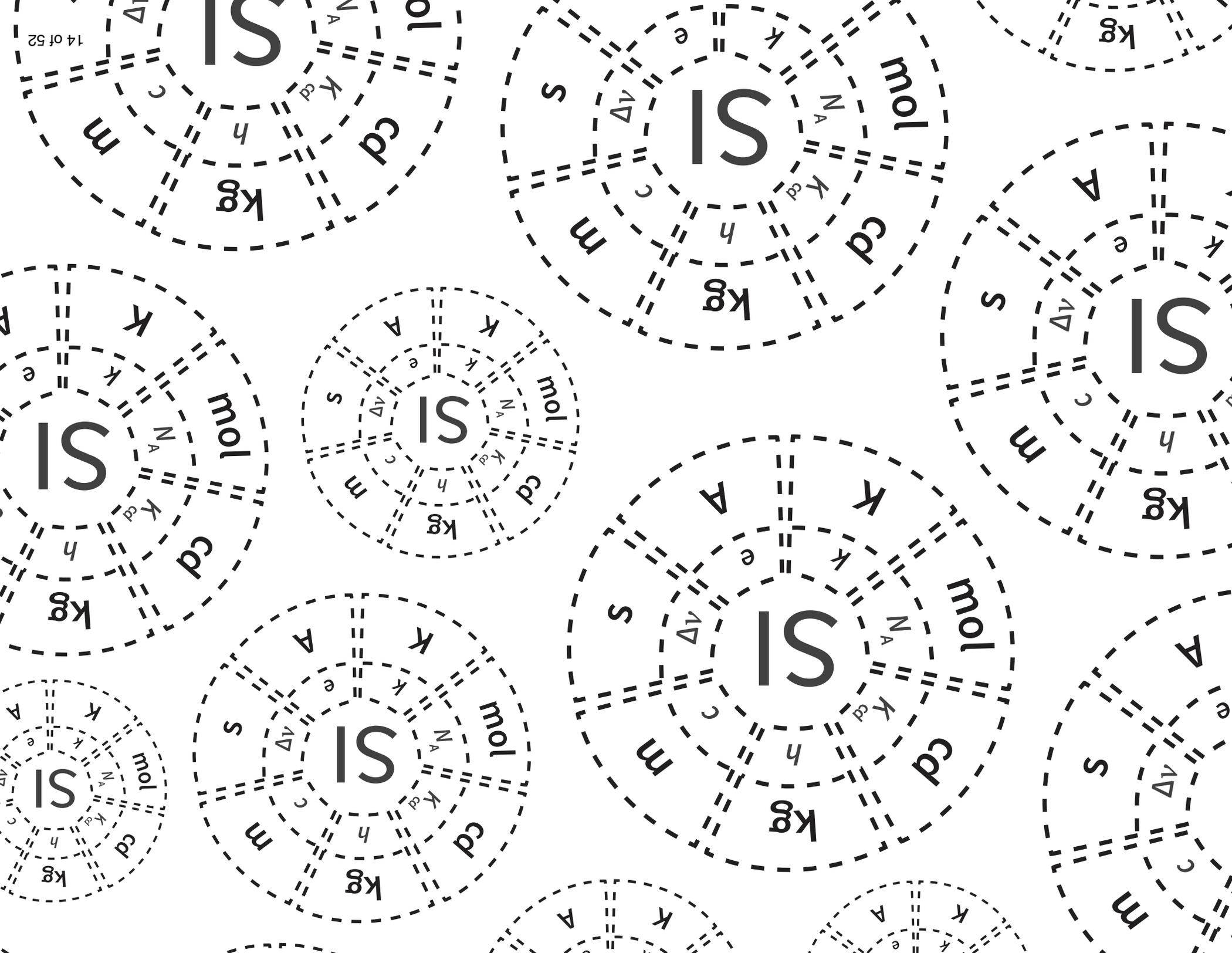
SI Derived Units with Special Names Name (Set E)

lumen

hertz

becquerel

gray



ohm

henry

farad

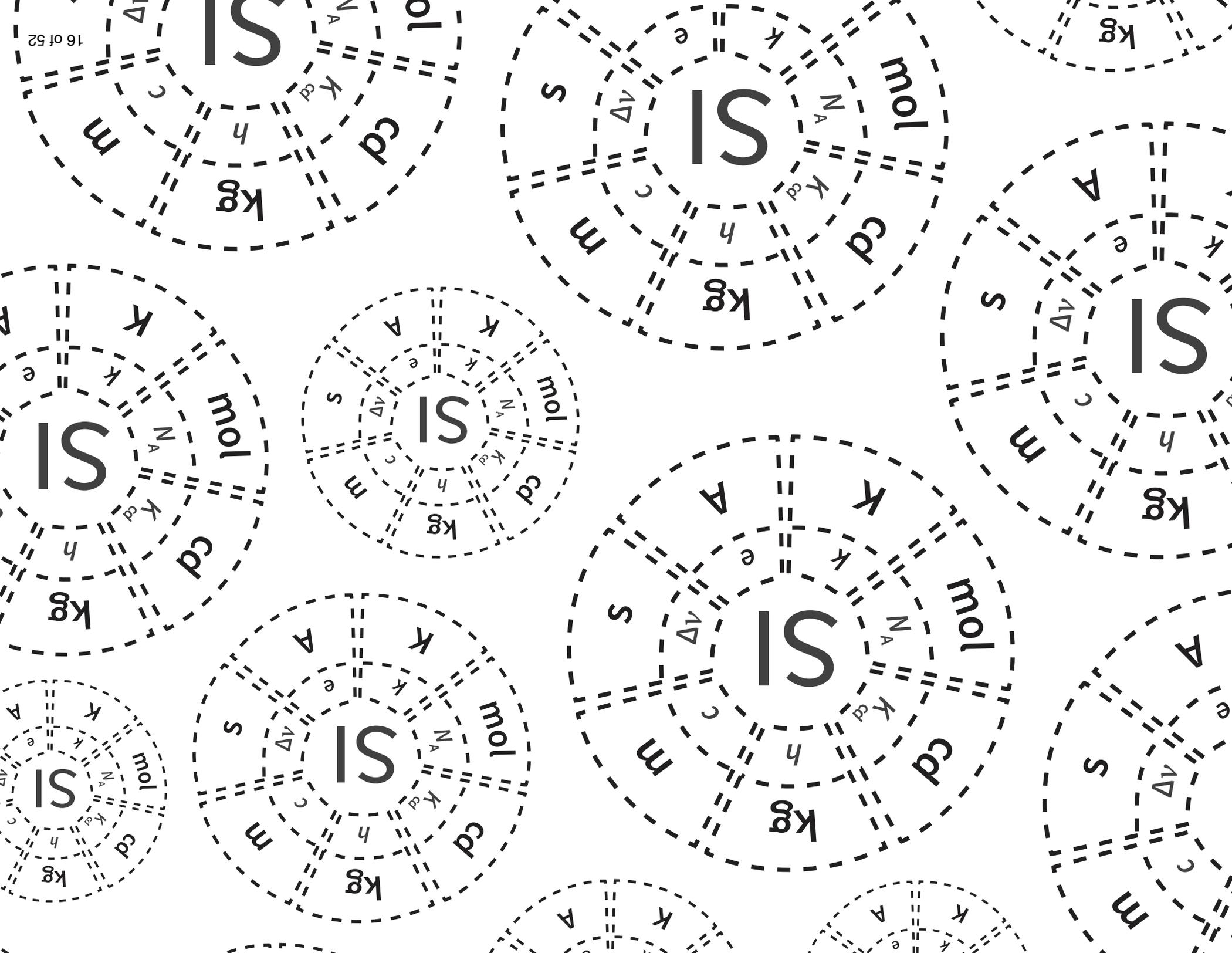
steradian

SI Derived Units with Special Names Name (Set E)

sievert

siemens

radian



SI
Derived Units
with Special
Names
Symbol
(Set F)

NIST OFFICE OF
WEIGHTS AND MEASURES

J
(N·m)

N
(kg·m/s²)

C
(A·s)

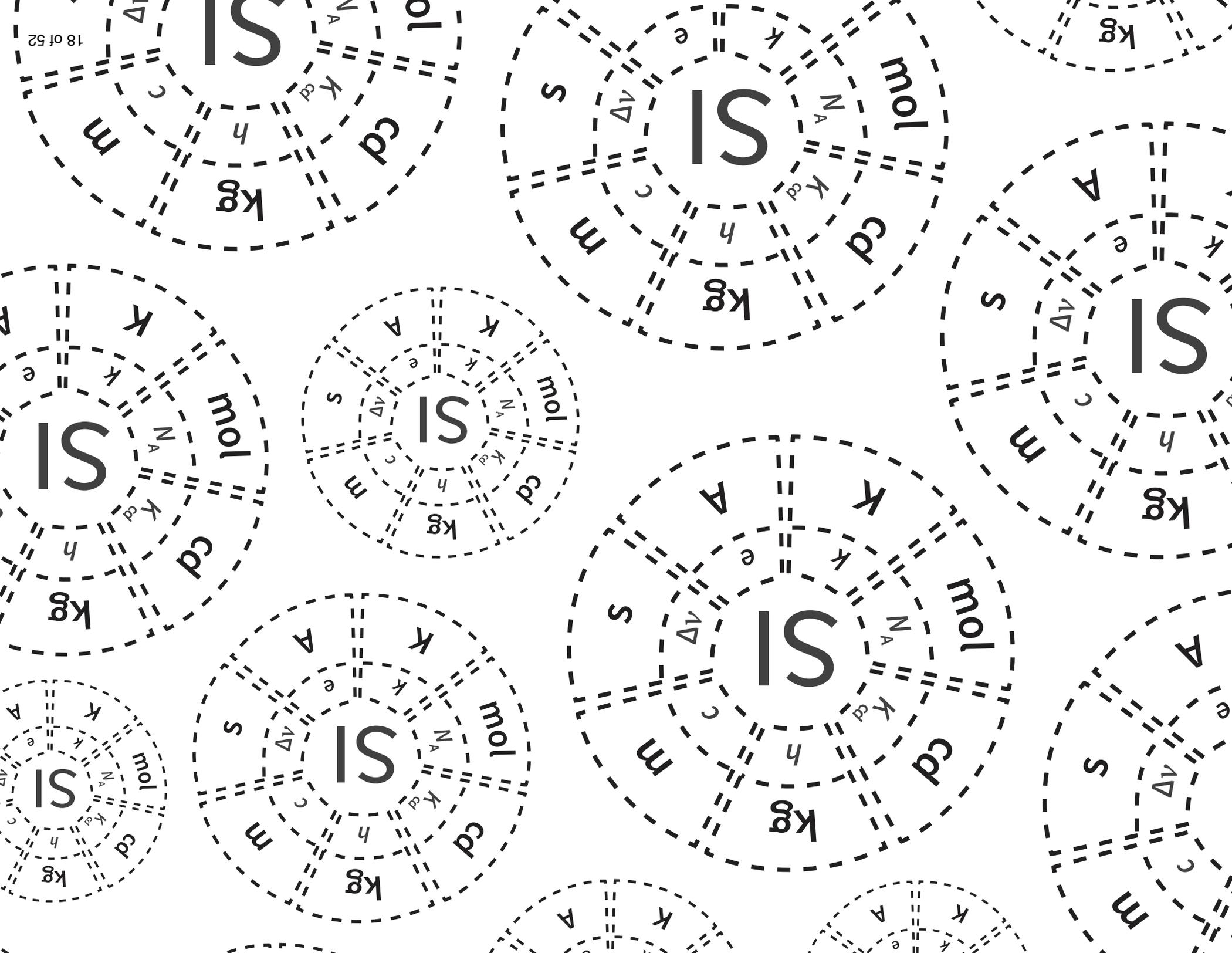
SI Derived Units with Special Names Symbol (Set F)

°C
(K)

kat
(mol/s)

lx
(lm/m²)

W
(J/s)



Pa
(N/m²)

V
(W/A)

Wb
(V·s)

T
(Wb/m²)

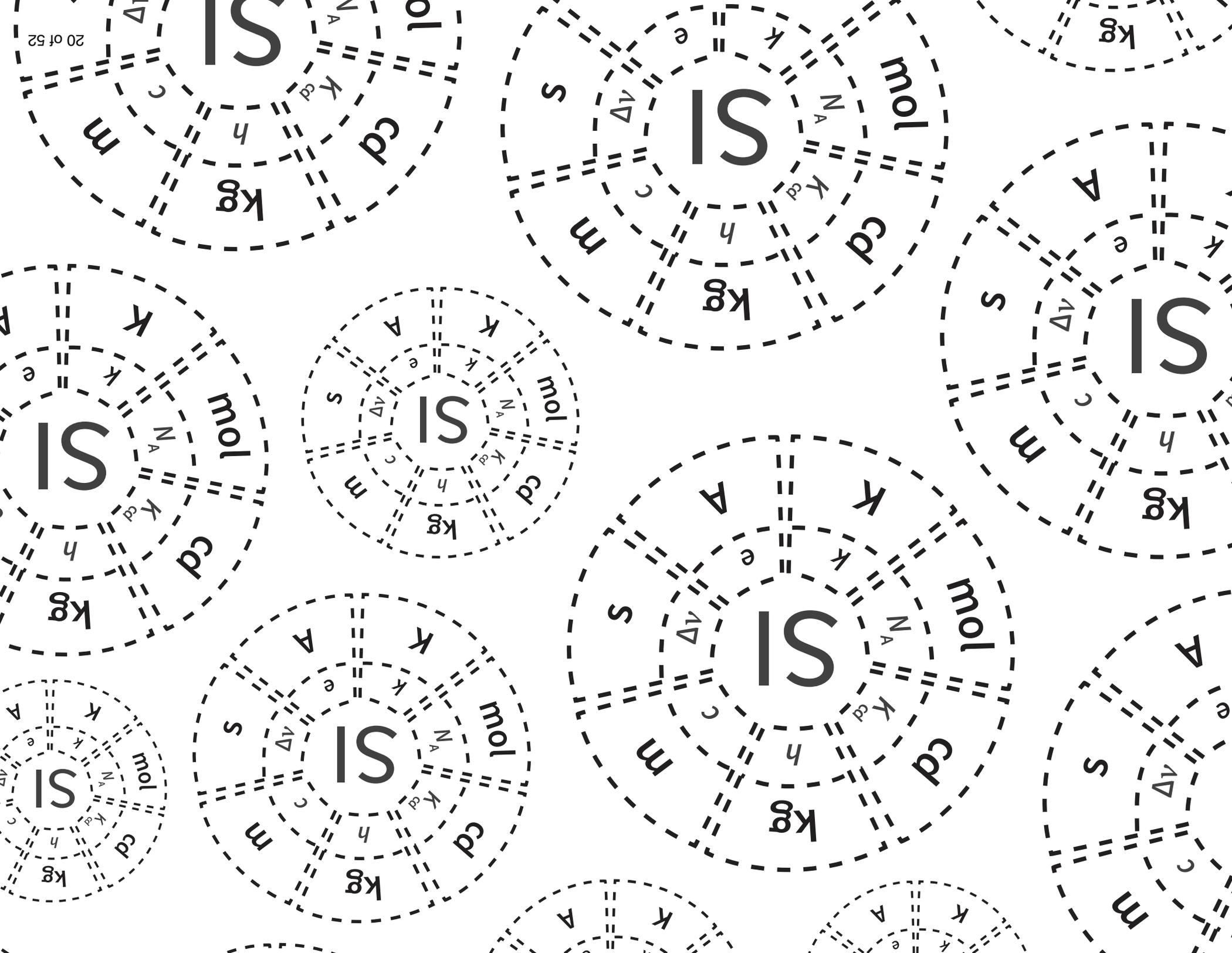
SI Derived Units with Special Names Symbol (Set F)

lm
(cd·sr)

Hz
(1/s)

Bq
(1/s)

Gy
(J/kg)



Ω
(V/A)

H
(Wb/A)

F
(C/V)

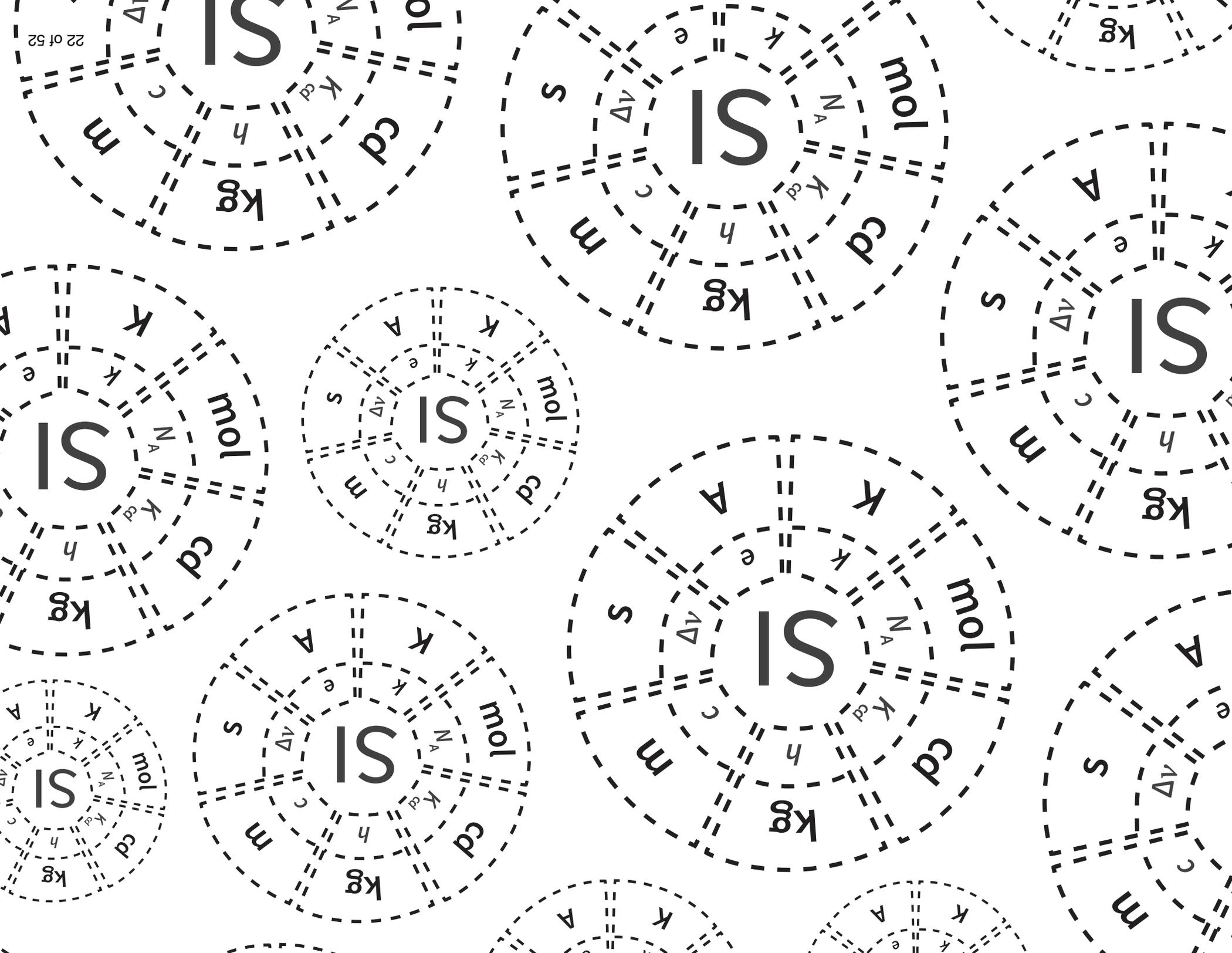
sr

SI Derived Units with Special Names Symbol (Set F)

Sv
(J/kg)

S
(1/ Ω)
or
(A/V)

rad



SI
Derived Units
with Special
Names
Quantity
(Set G)

NIST OFFICE OF
WEIGHTS AND MEASURES

energy, work,
amount of
heat

force

electric
charge

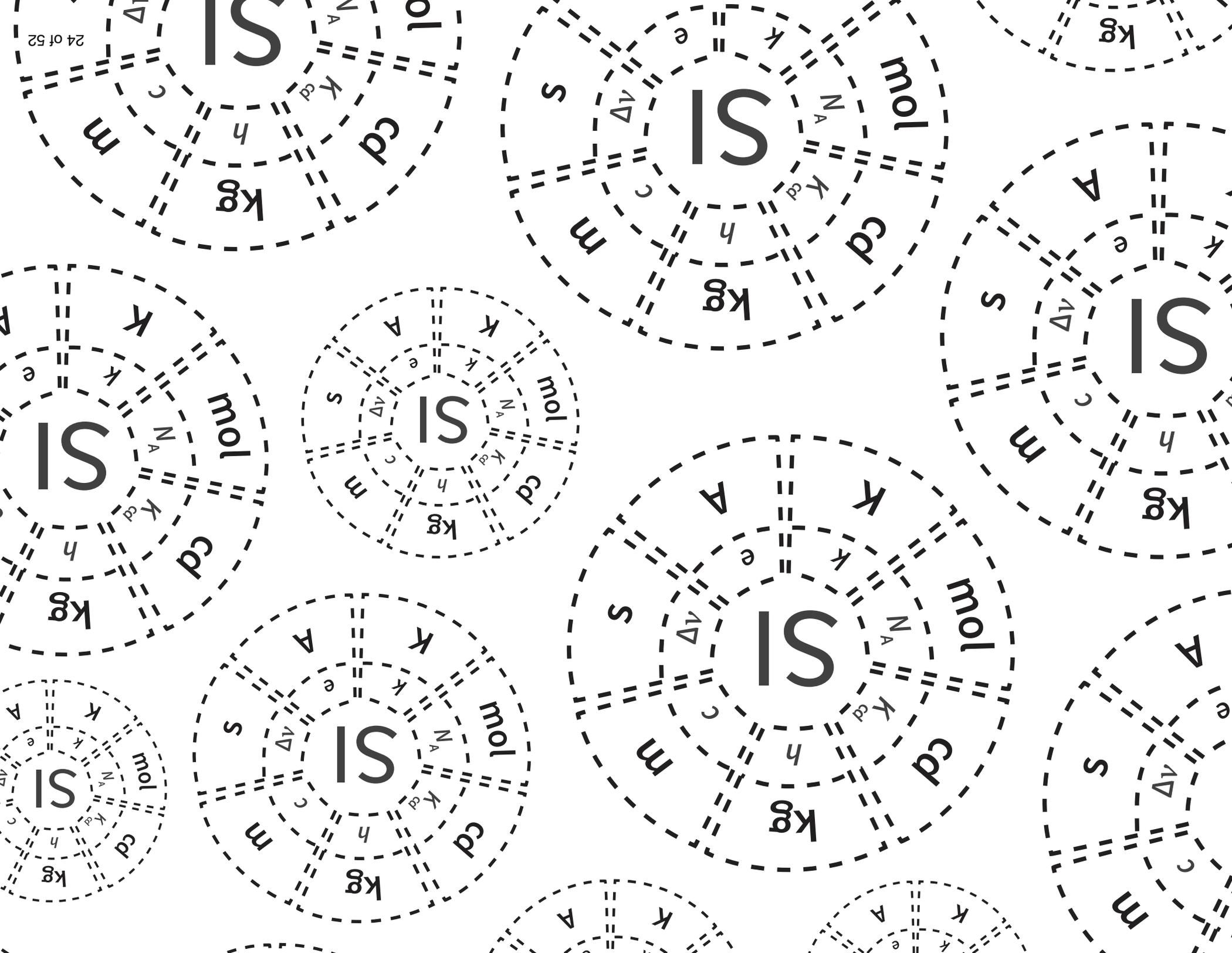
SI Derived Units with Special Names Quantity (Set G)

Celsius
temperature

catalytic
activity

illuminance

power, heat
flow rate,
radiant flux



pressure,
stress

voltage,
electromotive
force

magnetic
flux

magnetic
flux
density

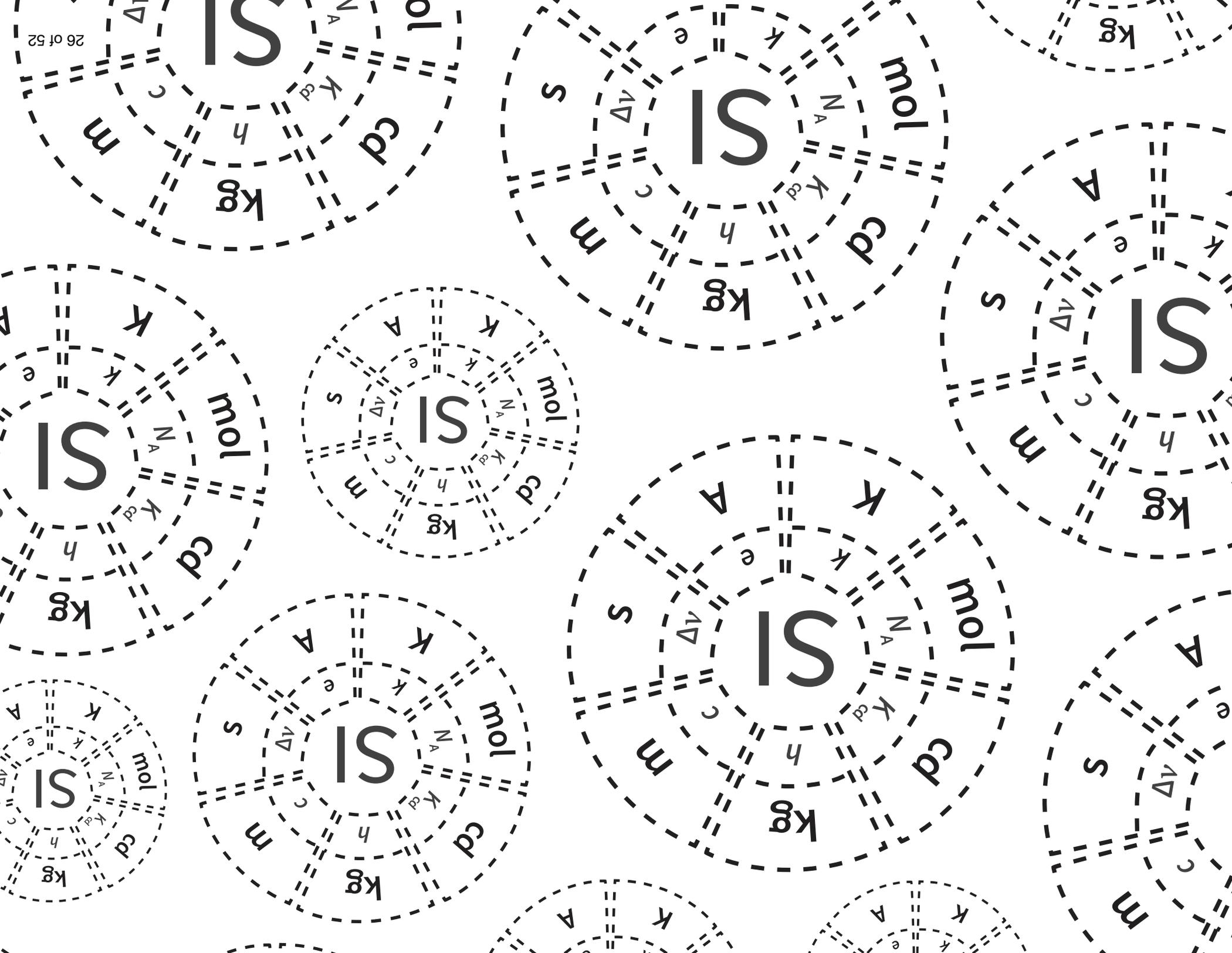
SI Derived Units with Special Names Quantity (Set G)

luminous
flux

frequency

activity
(radionuclide)

absorbed
dose



resistance

inductance

capacitance

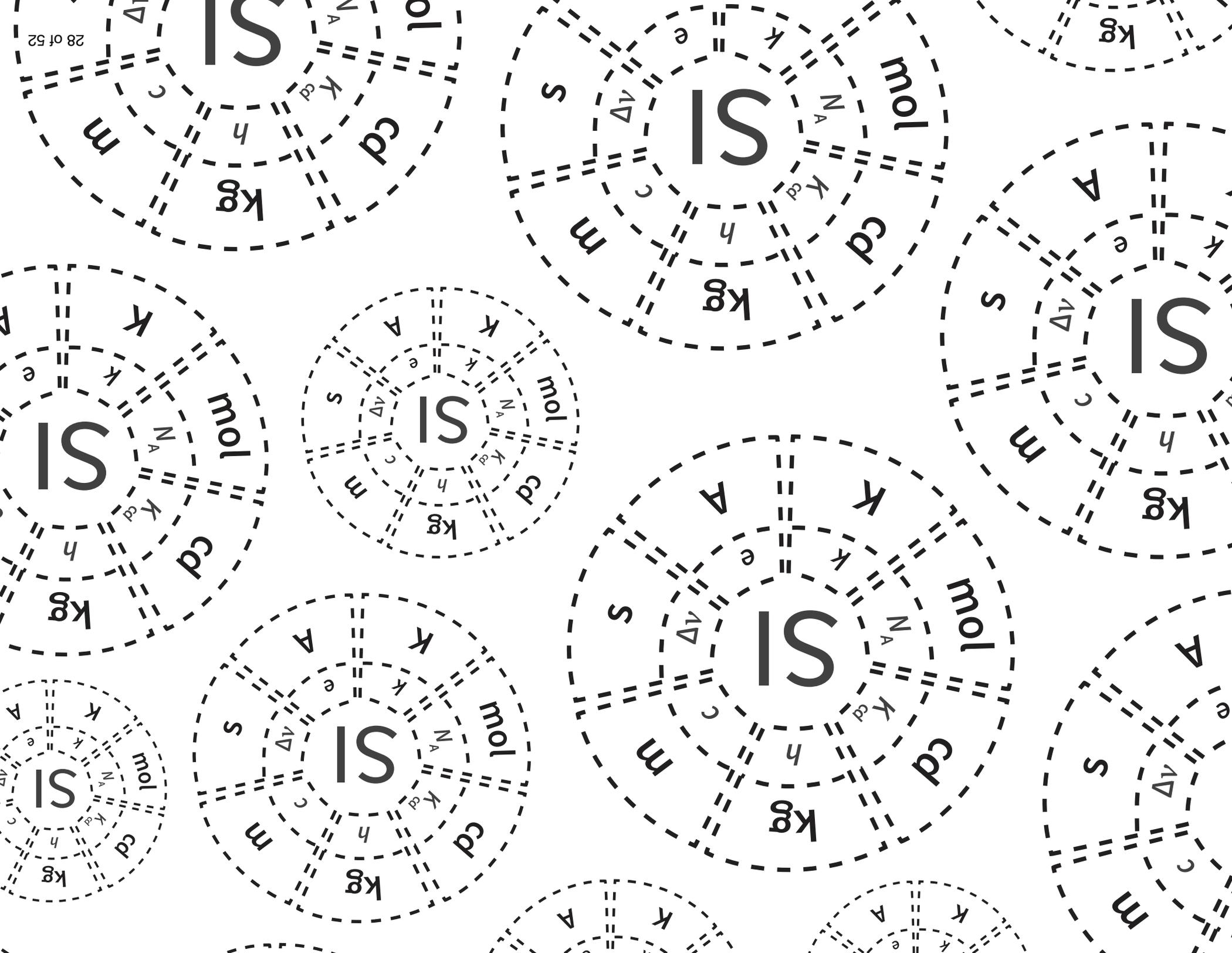
solid angle

SI Derived Units with Special Names Quantity (Set G)

dose
equivalent

conductance

plane angle



SI Prefixes
(Set H)

NIST OFFICE OF
WEIGHTS AND MEASURES

Name &
Symbol
(Large)

NIST OFFICE OF
WEIGHTS AND MEASURES

deka
(da)

hecto
(h)

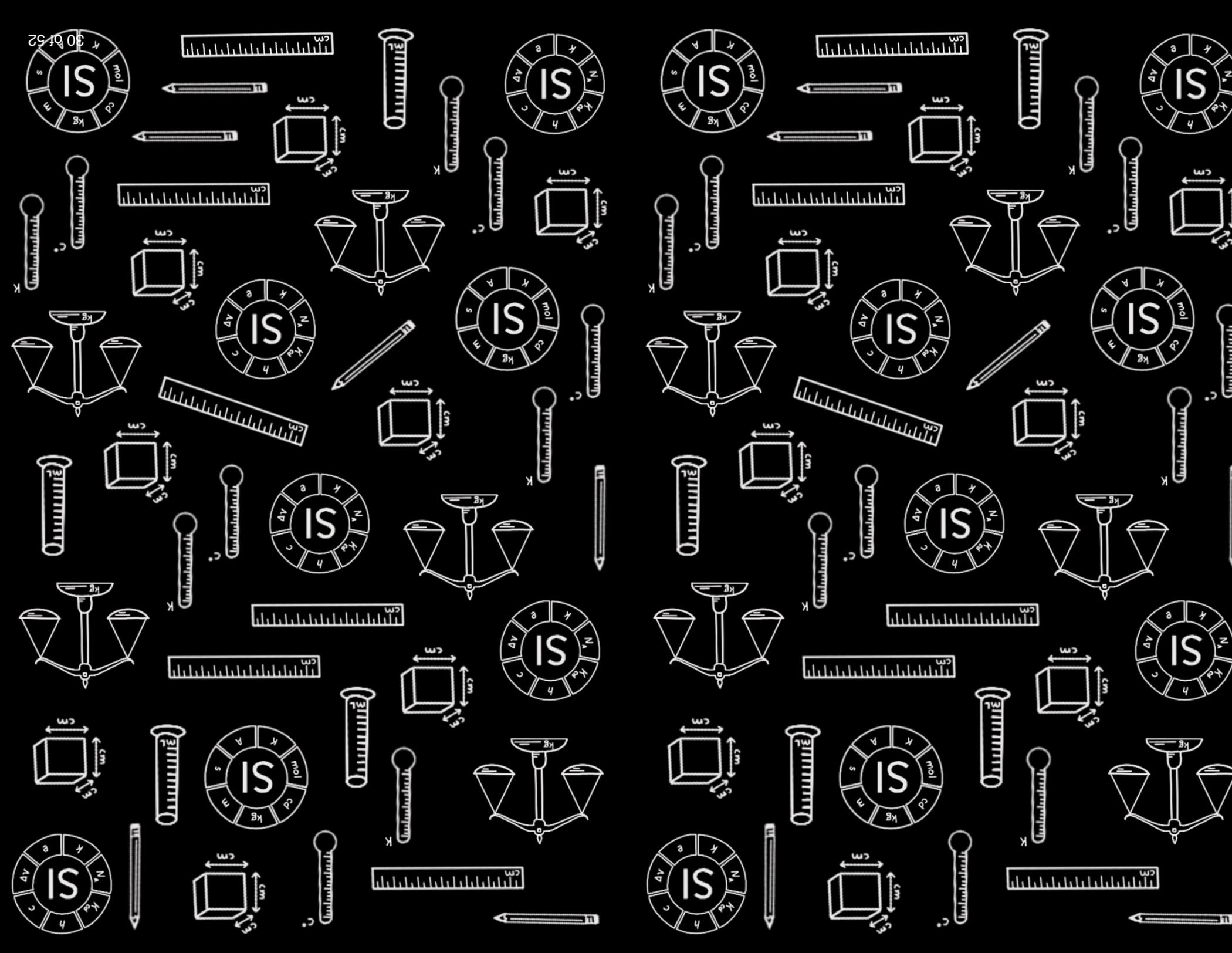
SI Prefixes (Set H) - Name & Symbol (Large)

kilo
(k)

mega
(M)

giga
(G)

tera
(T)



peta
(P)

exa
(E)

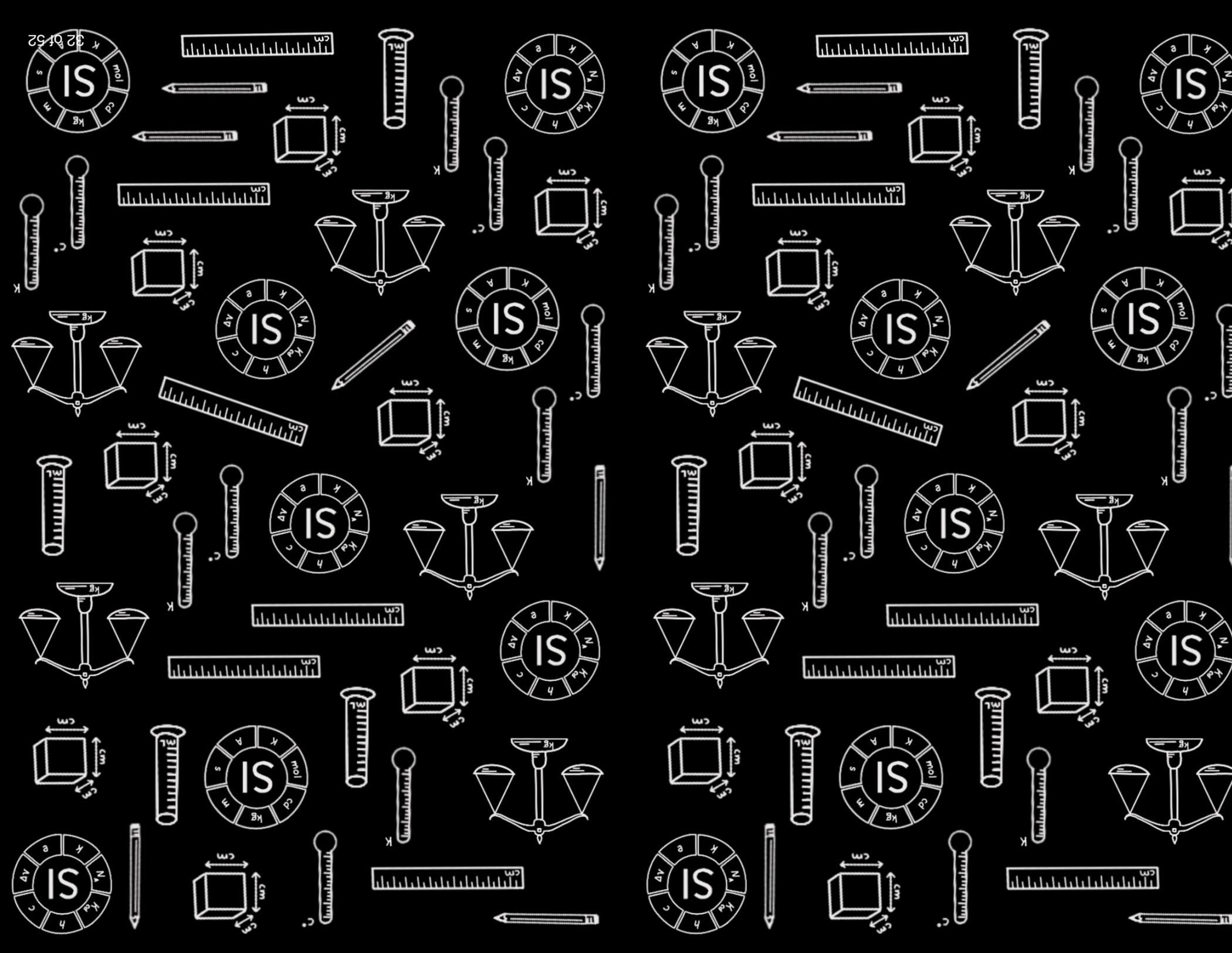
zetta
(Z)

yotta
(Y)

SI Prefixes (Set H) - Name & Symbol (Large)

ronna
(R)

quetta
(Q)



12 of 52

SI Prefixes
(Set H)

NIST OFFICE OF
WEIGHTS AND MEASURES

Factors
Large
(Set H)

10^1

10^2

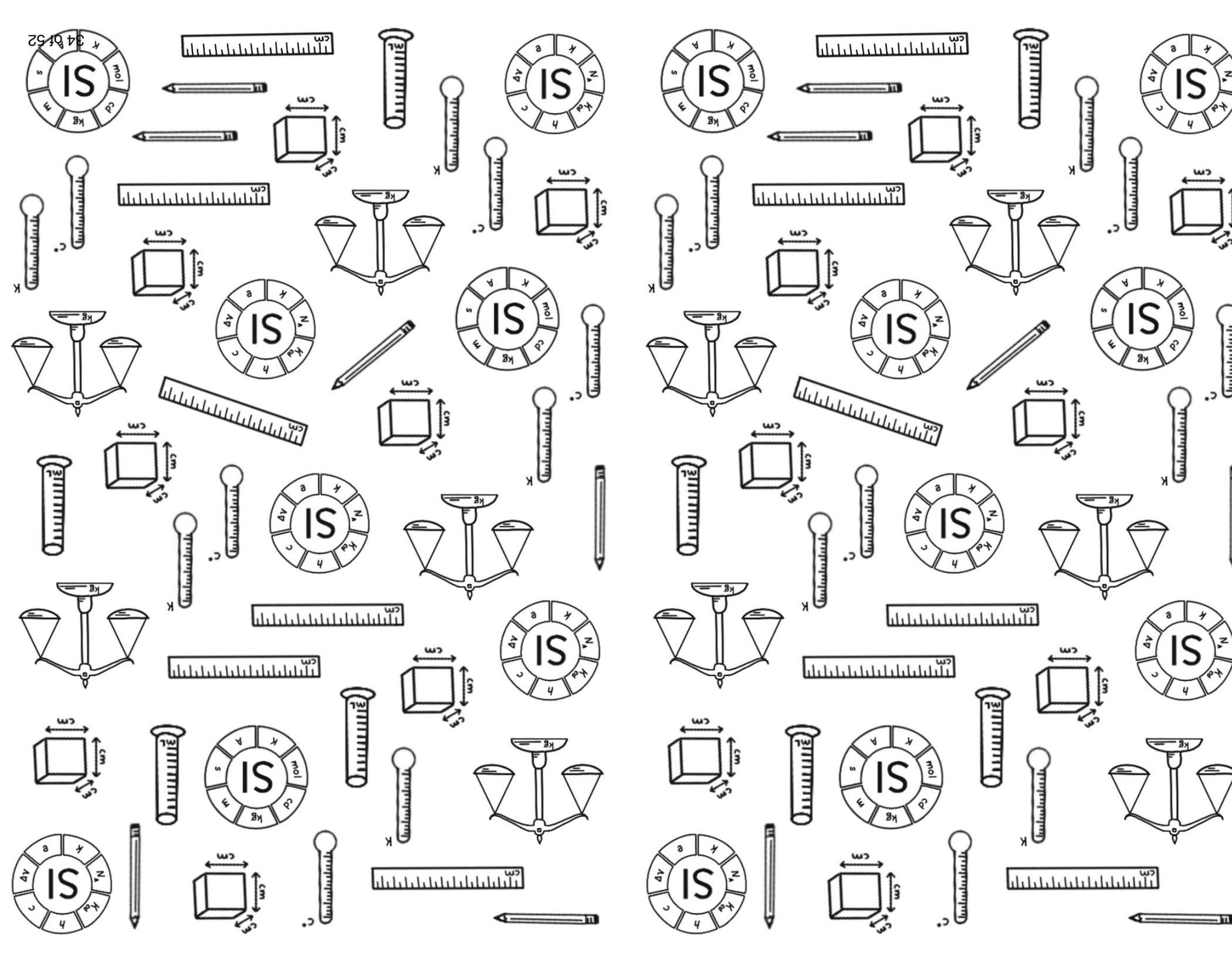
SI Prefixes (Set H) - Factors (Large)

10^3

10^6

10^9

10^{12}



10^{15}

10^{18}

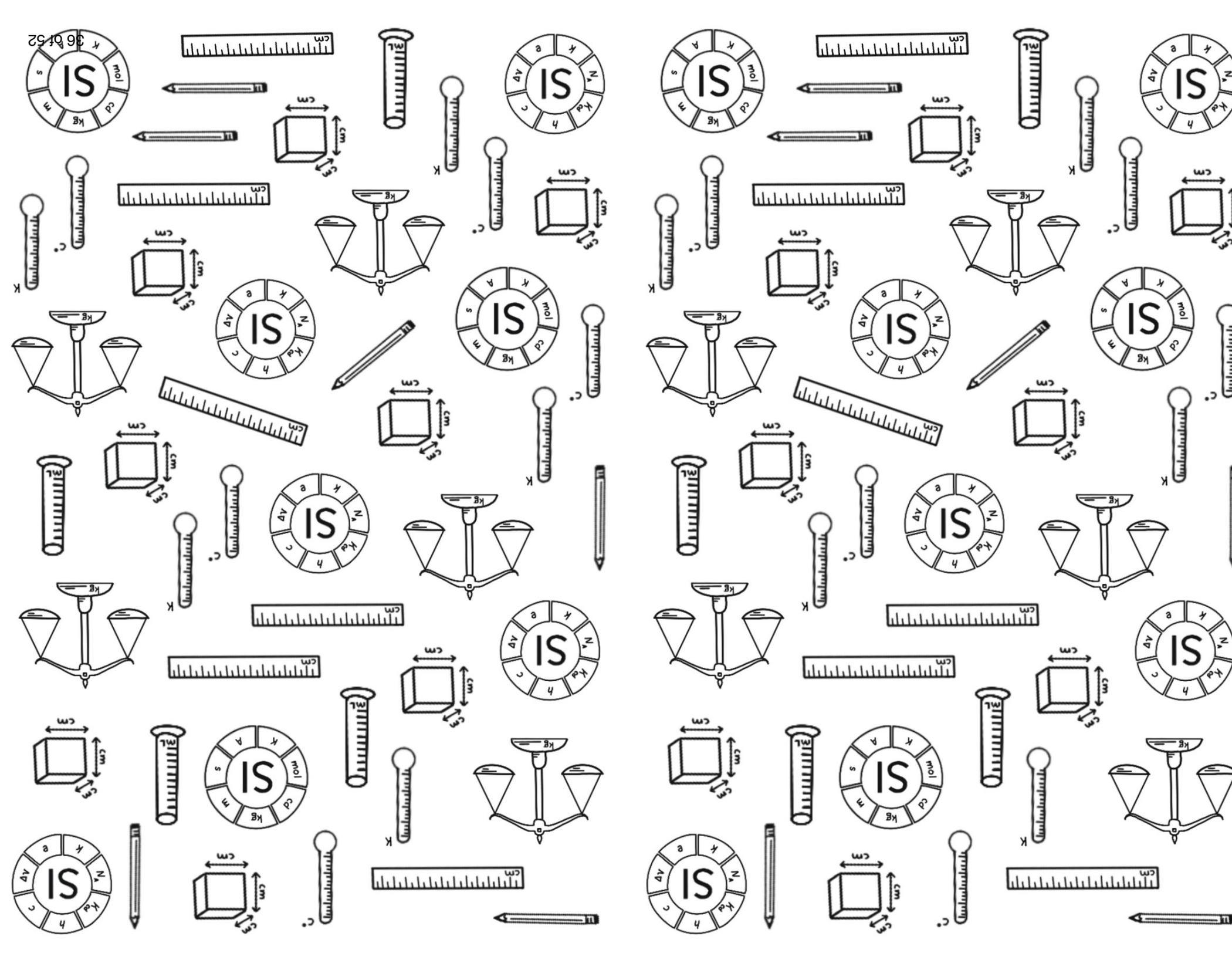
10^{21}

10^{24}

SI Prefixes (Set H) - Factors (Large)

10^{27}

10^{30}



SI Prefixes
(Set I)

NIST OFFICE OF
WEIGHTS AND MEASURES

Name &
Symbol
(Small)

NIST OFFICE OF
WEIGHTS AND MEASURES

deci
(d)

centi
(c)

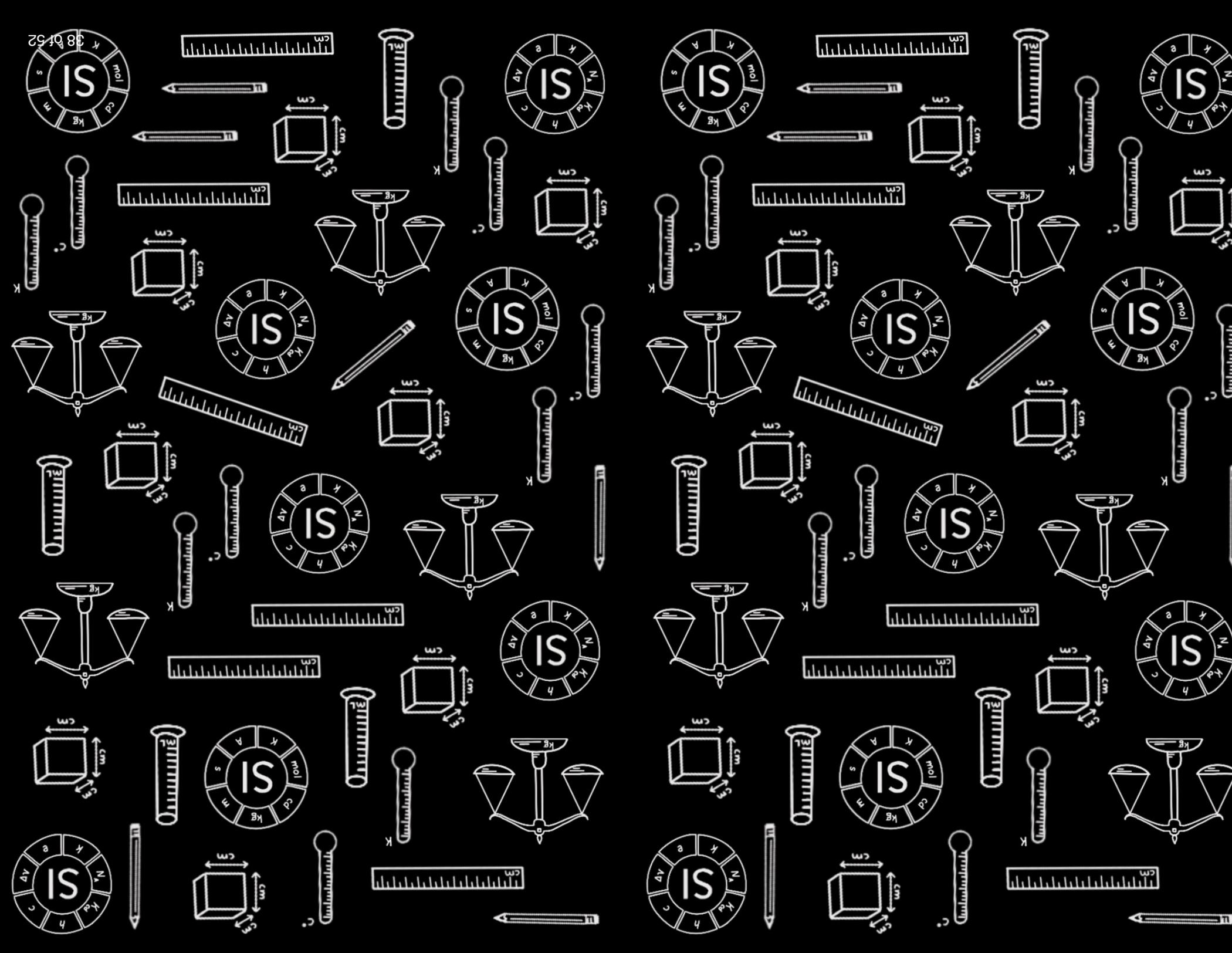
SI Prefixes (Set I) - Name & Symbol (Small)

milli
(m)

micro
(μ)

nano
(n)

pico
(p)



18 of 52

femto
(f)

atto
(a)

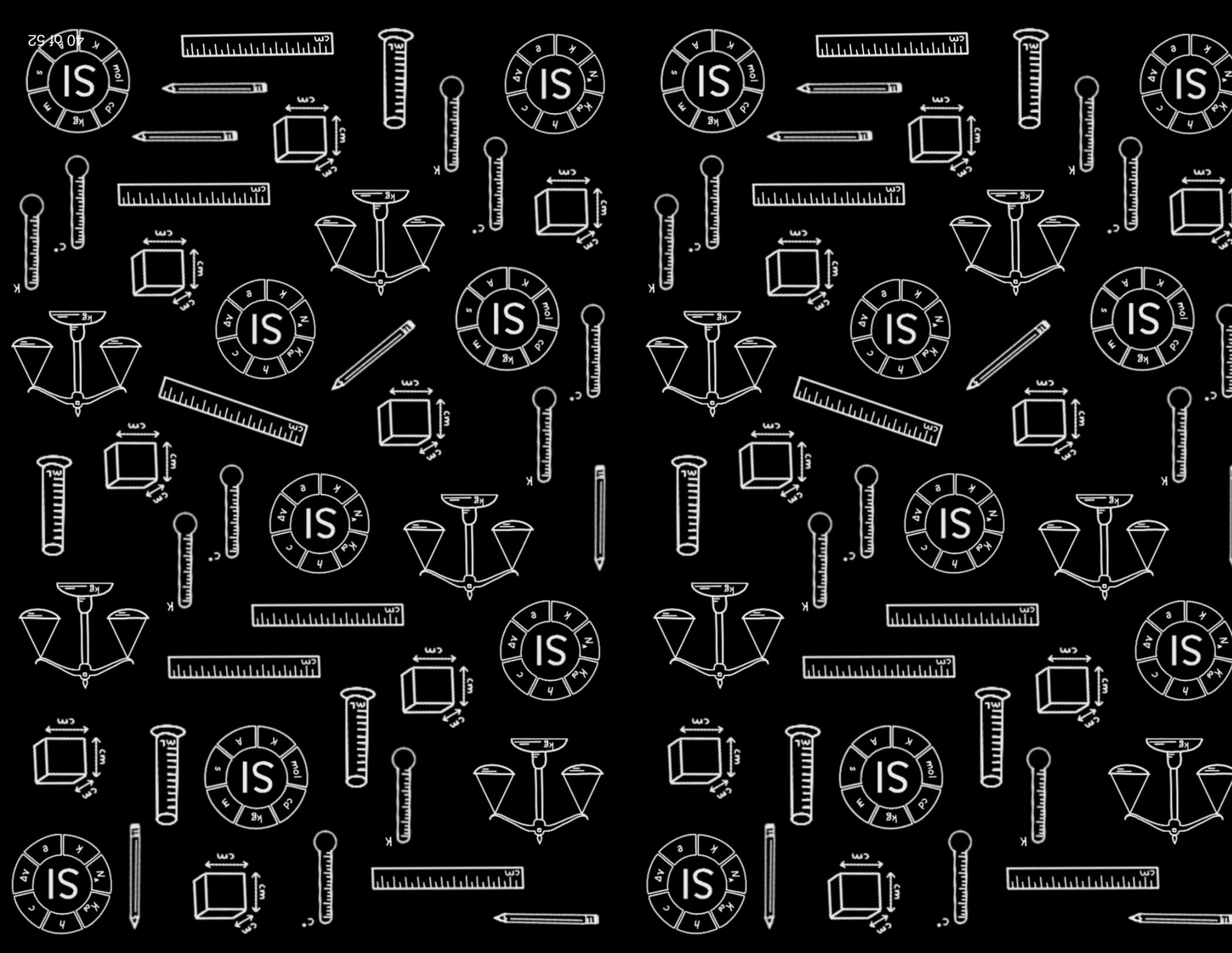
zepto
(z)

yocto
(y)

SI Prefixes (Set I) - Name & Symbol (Small)

ronto
(r)

quecto
(q)



SI Prefixes
(Set I)

NIST OFFICE OF
WEIGHTS AND MEASURES

Factors
Small
(Set I)

10^{-1}

10^{-2}

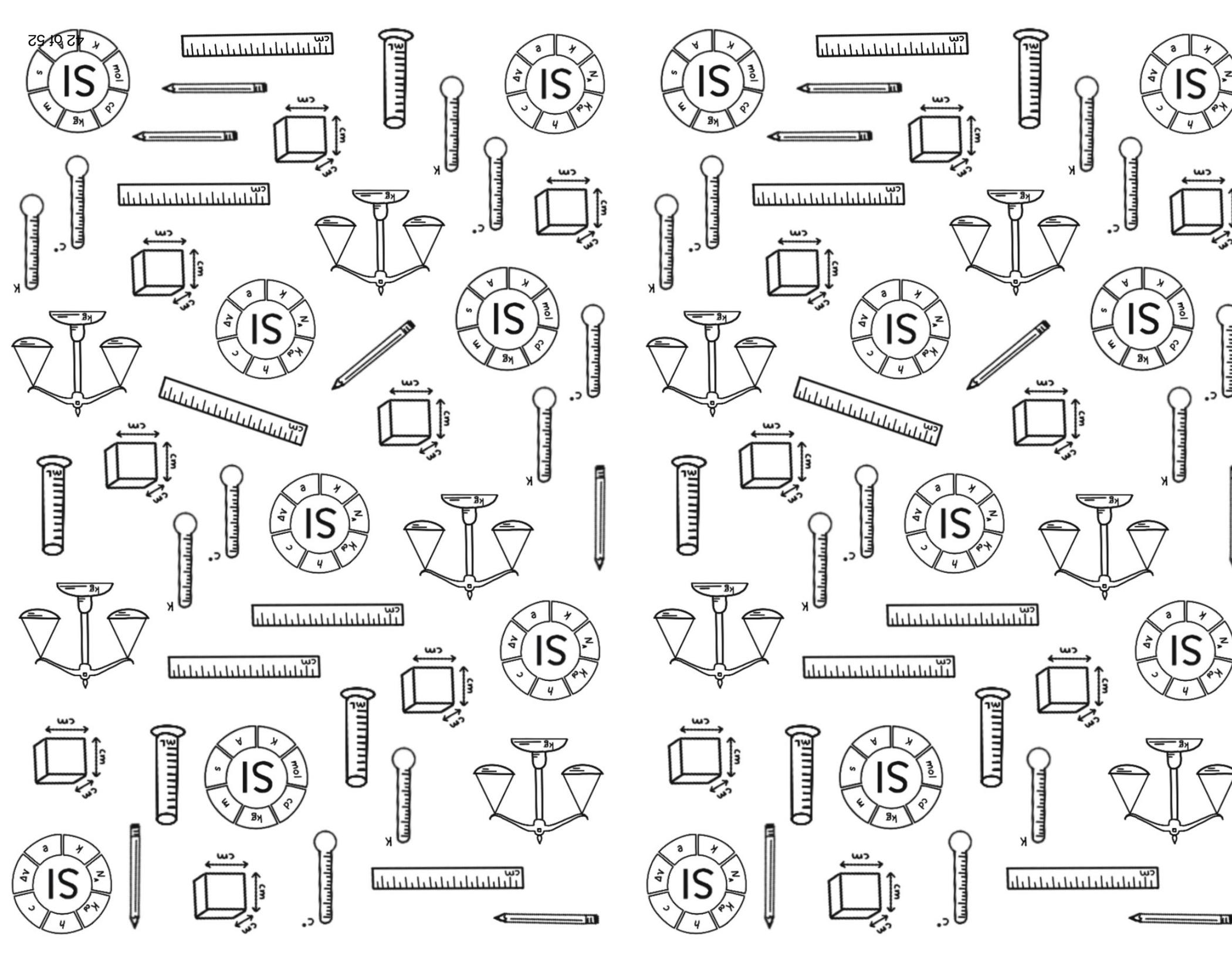
SI Prefixes (Set I) - Factors (Small)

10^{-3}

10^{-6}

10^{-9}

10^{-12}



10^{-15}

10^{-18}

10^{-21}

10^{-24}

SI Prefixes (Set I) - Factors (Small)

10^{-27}

10^{-30}

Metric Match-Up

Players: Multiplayer (max 4) or Single.

Difficulty Level: Difficult.

Time: 50 minutes (adjust as needed).

Introduction:

Dive into the world of units, symbols, and quantities! This educational card game is designed to build SI knowledge, and focuses on the relationships between the defining constants, base and derived units with special names. This activity is designed to supplement prior classroom discussion of the SI measurement system.

Materials:

- One complete set of the base units (**sets B, C, D**) or derived units (**sets E, F, G**) for the group. One set of the defining constants (**set A**) per player.
- SI Logos and Defining Constants Charts (**Resource 3 and 4**).
- Stopwatch or timing device.
- Score sheet (paper or whiteboard).

Objective:

The goal is to successfully match the base units (**sets B, C, D**) and derived units (**sets E, F, G**) with their corresponding defining constants (**set A**). Players compete to accurately determine the defining constants used to derive each base and derived unit.

Game Tips:

- Review the BIPM SI logos (**Resource 3**), which illustrate the defining constants used to define each of the seven SI base units.
- Become familiar with the relationship between the base and derived units with special names, and their respective defining constants (**Resource 4**).

Game Modifications:

- For a cooperative variant, players work in pairs to determine matches.
- Increase the time limit per round to decrease the difficulty level.

Setup:

Select the appropriate card sets depending on the game variation, select either the base units set (**set B, C, D**) or the derived units set (**set E, F, G**). Place each card pile facedown in the center. Additionally, each player should hold a set of the defining constants cards (**set A**).

Base Units Variation:

- Round 1: **set B** (Name).
- Round 2: **set C** (Symbol).
- Round 3: **set D** (Quantity).

Derived Units Variation:

- Round 1: **set E** (Name).
- Round 2: **set F** (Symbol).
- Round 3: **set G** (Quantity).

Gameplay:

1. Pick a player to turn over one card from the center pile.
2. Start timer for 20 seconds. During this time, each player places down the defining constant card(s) required to derive the unit displayed.
3. When the timer ends, move from player to player to verify each match using **Resource 3 and 4**.
4. Award 1 point for each valid match and record on the score sheet.
5. Example: The SI base unit **Ampere** name card is revealed from the pile in the center. Players who only placed down the elementary charge and cesium hyperfine splitting frequency cards earn 1 point. Other combinations do not earn a point.

Determining the Winner:

Points are awarded to each player for each accurate match. Player points are totaled each round. Each round of points are added together to determine the final score for each player. The player(s) with the highest score after three rounds wins.

Find the Match: Units

Players: Multiplayer (max 6) or Single.

Difficulty Level: Moderate to Difficult.

Time: 50 minutes (adjust as needed).

Introduction:

This card game is designed to build familiarity with the International System of Units (SI, commonly known as the metric system) while applying memory skills. With its simple rules and engaging objectives, this educational game offers an enjoyable opportunity for students to successfully apply the basic elements of the measurement system.

Materials:

- One complete set of the base units (**sets B, C, D**) or one complete set of the derived units (**sets E, F, G**).
- SI Base Units Chart (**Resource 2**).

Objective:

The primary objective of the game is to successfully match the cards between sets. In each round, match the corresponding name, symbol, and quantity cards.

Game Tips:

It is crucial to pay close attention to every turn in the game. Remembering the location of cards is required to form a pair.

Game Modifications:

- The number of cards revealed can be increased or decreased to vary the difficulty level of each round.
- For a cooperative variant, players work in pairs to determine matches.

Setup:

Select the appropriate card sets depending on whether you are playing with the base units or the derived units cards, shuffle two sets and arrange them face down in rows and columns.

Base Units Variation:

- Round 1: **sets B and C** (Name and Symbol).
- Round 2: **sets B and D** (Name and Quantity).
- Round 3: **sets C and D** (Symbol and Quantity).

Derived Units Variation:

- Round 1: **sets E and F** (Name and Symbol).
- Round 2: **sets E and G** (Name and Quantity).
- Round 3: **sets F and G** (Symbol and Quantity).

Gameplay:

1. Payers take turns flipping over either 6 cards (easy level) or 4 cards (moderate level) from the table.
 - If these cards DO form a valid pair the player collects the pair and earns an additional turn.
 - If these cards DO NOT form a valid pair, they must be flipped back down in the original position, and it becomes the next player's turn.
 - Participants may validate a correct pair by using the SI Base Units chart (**Resource 2**).
2. Players continue taking turns until all the cards have been successfully paired.

Determining the Winner:

Once all the pairs have been correctly matched, players tally the number of cards collected throughout the game. The player or team with the highest number of pairs emerges as the champion.

Find the Match: Prefixes

Players: Multiplayer (max 4) or Single.

Difficulty Level: Easy to Moderate.

Time: 50 minutes (adjust as needed).

Introduction:

This card game is designed to build familiarity with the International System of Units (SI, commonly known as the metric system) while applying memory skills. With its simple rules and engaging objectives, this educational game offers an enjoyable opportunity for students to successfully apply the SI prefixes.

Materials:

- One complete set of the SI Prefixes decks **sets H and I** (large and small).
- SI Prefixes chart (**Resource 5**).

Objective:

The primary objective of the game is to uncover and match the cards in the set. In each round, match the corresponding SI prefixes name/symbol cards to the factor cards.

Game Tips:

It is crucial to pay close attention to every turn in the game. Remembering the location of cards is required to form a pair.

Game Modifications:

- The number of cards revealed can be increased or decreased to vary the difficulty level of each round.
- For a cooperative variant, players work in pairs to determine matches.

Setup:

Shuffle one SI Prefixes set, either large or small (**set H or I**) and arrange them face down in rows and columns.

- Round 1: **set H** (large name/symbol and factor).
- Round 2: **set I** (small name/symbol and factor).
- Round 3: **combine sets H and I** (large and small).

Gameplay:

1. The players take turns flipping over either 6 cards (easy level) or 4 cards (moderate level) from the table, meaning 3 or 2 white cards AND 3 or 2 black cards.
 - If these cards DO form a valid pair the player collects the pair and earns an additional turn.
 - If these cards DO NOT form a valid pair, they must be flipped back down in the original position, and it becomes the next player's turn.
 - Participants may validate a correct pair by using the SI Prefixes Chart Resource (**Resource 5**).
2. Players continue taking turns until all the cards have been successfully paired.

Determining the Winner:

Once all the pairs have been correctly matched, players tally the number of cards collected throughout the game. The player or team with the highest number of cards emerges as the champion.

Learner Developed Game (Template)

Players:
Difficulty Level:
Time:

Introduction:

Materials:

Objective:

Game Tips:

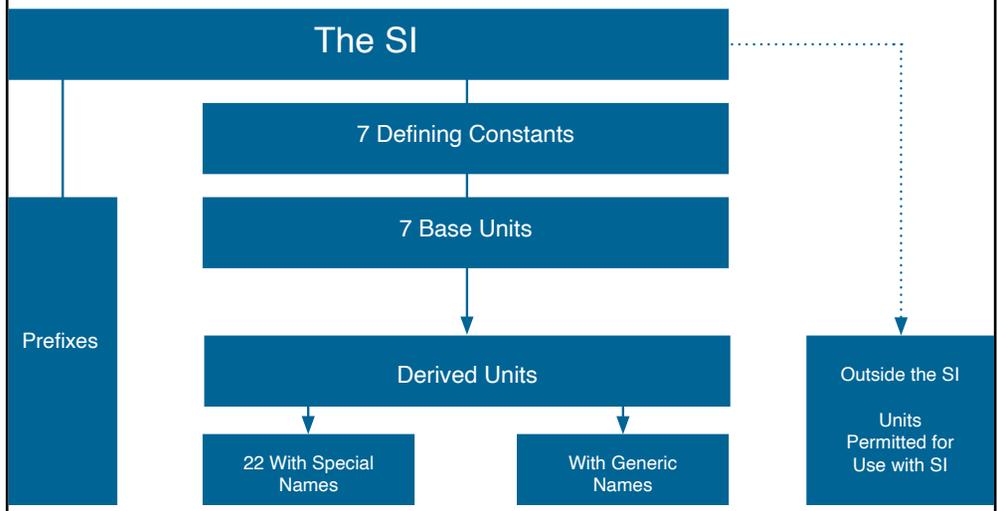
Determining the Winner:

Setup:

Gameplay:

Game Modifications:

1 SI MODEL

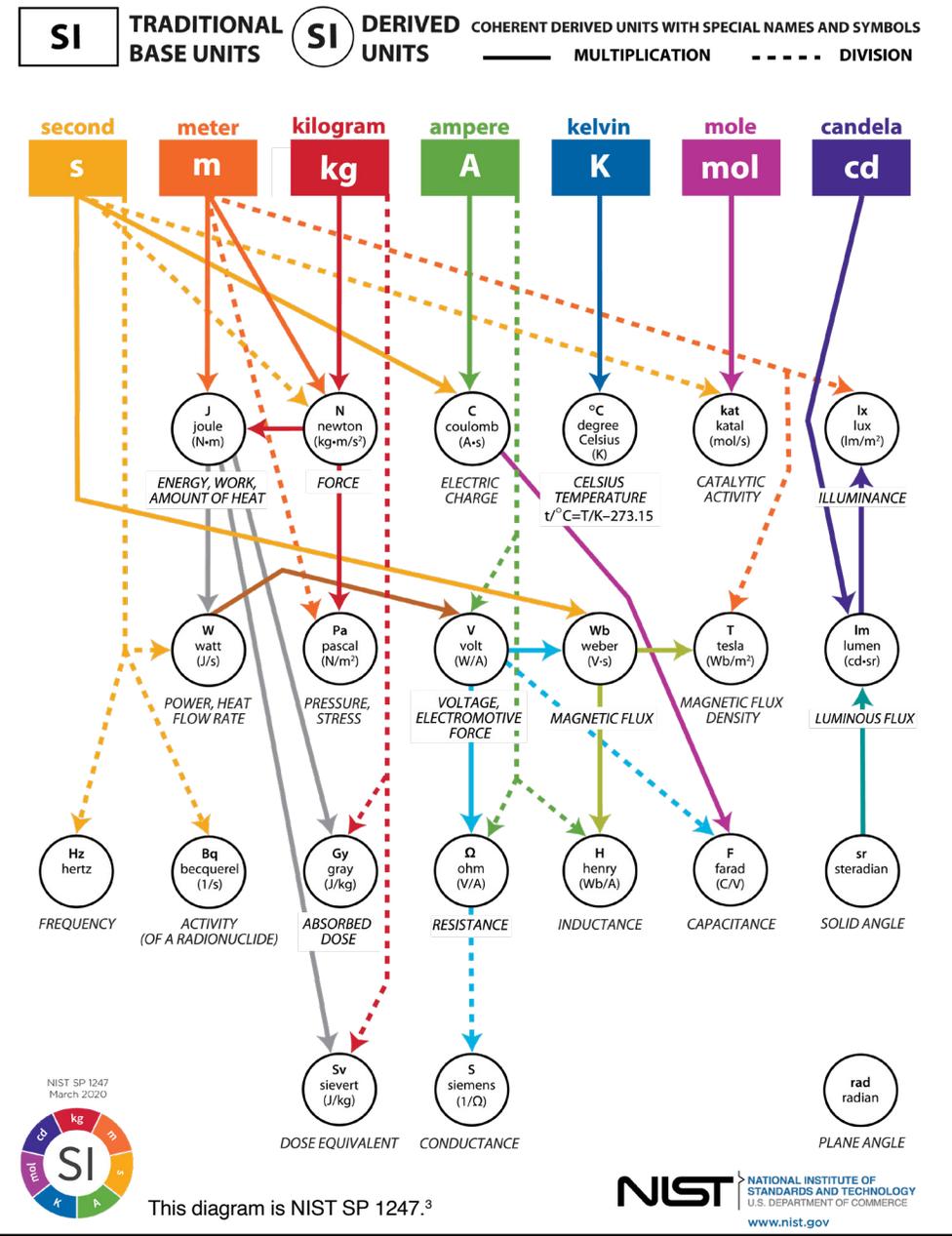


This diagram is a graphical model of the International System of Units (SI), adapted from NIST TN 938.²

DEFINING CONSTANTS

1. Hyperfine transition frequency of Cs (ΔV_{Cs})
2. Speed of light in vacuum (c)
3. Planck constant (h)
4. Elementary charge (e)
5. Boltzmann constant (k)
6. Avogadro constant (N_A)
7. Luminous efficacy (K_{cd})

2 SI BASE UNITS



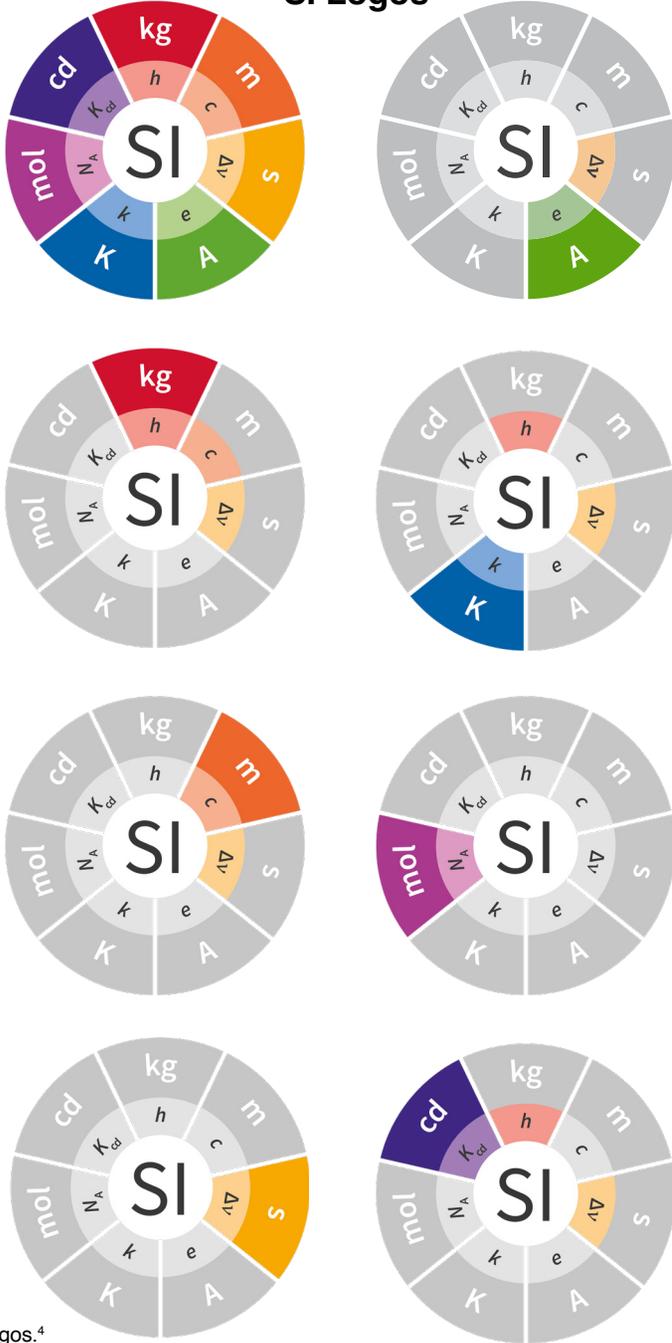
This diagram is NIST SP 1247.³



Resources

3

SI Logos



Official BIPM logos.⁴

4

Named SI Units and their Defining Constants⁵

Unit	ΔV_{Cs}	c	h	e	N_A	k	K_{Cd}
mol (mole)					X		
C (coulomb)				X			
s (second)	X						
Hz (hertz)	X						
Bq (becquerel)	X						
A (ampere)	X			X			
m (meter)	X	X					
Gy (gray)	X	X					
Sv (sievert)	X	X					
kat (katal)	X				X		
kg (kilogram)	X	X	X				
N (newton)	X	X	X				
Pa (pascal)	X	X	X				
J (joule)	X	X	X				
W (watt)	X	X	X				
V (volt)	X	X	X	X			
F (farad)	X	X	X	X			
Ω (ohm)	X	X	X	X			
S (siemens)	X	X	X	X			
Wb (weber)	X	X	X	X			
T (tesla)	X	X	X	X			
H (henry)	X	X	X	X			
K (kelvin)	X	X	X			X	
C (celsius)	X	X	X			X	
cd (candela)	X	X	X				X
lm (lumen)	X	X	X				X
lx (lux)	X	X	X				X

Resources

5 SI Prefixes Chart⁶

FACTOR	NAME	SYMBOL
10 ³⁰	quetta	Q
10 ²⁷	ronna	R
10 ²⁴	yotta	Y
10 ²¹	zetta	Z
10 ¹⁸	exa	E
10 ¹⁵	peta	P
10 ¹²	tera	T
10 ⁹	giga	G
10 ⁶	mega	M
10 ³	kilo	k
10 ²	hecto	h
10 ¹	deka	da
10 ⁻¹	deci	d
10 ⁻²	centi	c
10 ⁻³	milli	m
10 ⁻⁶	micro	μ
10 ⁻⁹	nano	n
10 ⁻¹²	pico	p
10 ⁻¹⁵	femto	f
10 ⁻¹⁸	atto	a
10 ⁻²¹	zepto	z
10 ⁻²⁴	yocto	y
10 ⁻²⁷	ronto	r
10 ⁻³⁰	quecto	q

6

Website QR Codes



- SI Redefinition I NIST



- SI Units I NIST



- Meet the Constants I NIST



- Metric (SI) Prefixes I NIST



- Teach the New SI I NIST



- Special Publication 330 I NIST

Summary

Use the SI Units Card Deck to learn the International System of Units (SI). Game activities divide major elements of the SI measurement system into chunks and reinforce their relationships: 1) defining constants, 2) base units, 3) derived units with special names, and 4) prefixes. This resource may be used by individual students or small teams in both formal and informal learning settings. Teachers are encouraged to frequently bring the SI into their classrooms! U.S. educators may obtain a free set of metric education classroom resources. Contact the NIST Metric Program at TheSI@nist.gov and include your name, school, subject, grade level, phone number, and U.S. mailing address.

This publication was designed and developed by Dinelka Jagoda, University of Maryland, in cooperation with mentor Elizabeth Benham, NIST Metric Program, to fulfill the research requirements of a NIST Professional Research Experience Program (PREP) and Summer Undergraduate Research Fellowship (SURF) internship. Please share comments and feedback to improve this educational resource with TheSI@nist.gov.

References:

- ¹ Benham, E. (2022). *Top 10 Tips for Teaching the Metric System*, National Institute of Standards & Technology (NIST) Taking Measure blog, <https://www.nist.gov/blogs/taking-measure/top-10-tips-teaching-metric-system>.
- ² Milton, Hans J. National Bureau of Standards (NBS) Technical Note (TN) 938 (1977). *Recommended practice for the use of metric (SI) in building design and construction*, <https://doi.org/10.6028/NBS.TN.938>.
- ³ Dill, K., Newell, D., and Tiesinga, E., NIST Special Publication (SP) 1247 (2020). *SI Base Units Relationships Poster*, <https://www.nist.gov/pml/owm/si-base-units-relationships-poster-sp-1247>.
- ⁴ International Bureau of Weights and Measures (BIPM), *Promotion of the SI*, <https://www.bipm.org/en/measurement-units/si-promotion>.
- ⁵ Stasiewicz, G. (2018). *Revamped SI measurement system approved*, Physics Today, <https://pubs.aip.org/physicstoday/Online/5005/Revamped-SI-measurement-system-approved>.
- ⁶ Newell, D. and Tiesinga, E. NIST Special Publication (SP) 330 (2019). *The International System of Units (SI)*, <https://www.nist.gov/pml/special-publication-330>.

